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ART. I.—*Description of an Ancient Sepulchral Mound near Newark, Ohio;* by O. C. MARSH, F.G.S.[1]

IN the first volume of the Smithsonian Contributions Messrs. Squier and Davis have ably described the most important of those ancient monuments of the Mississippi Valley, which render that region so interesting to the student of American archæology. By discarding vague speculation, which had been the prominent fault of most previous investigators, and adopting that rigid method of research, inaugurated so successfully by Scandinavian antiquaries, these authors were enabled to embody in their work all that was valuable in previous accounts, and to add much new and important information concerning that ancient population of this country, who have left behind them so many imposing structures. The subsequent researches of Squier, Latham, and others, have thrown additional light upon this interesting subject, so that at the present time the "Mound-builders" can no longer be regarded as an unknown people, although both tradition and history are silent in regard to them.

Few of these ancient monuments of the West have attracted more attention than the group of 'Enclosures,' or 'Forts,' near Newark, Ohio, which have long been celebrated on account of their great extent, and remarkable regularity. They consist mainly of elaborate earthworks, in the form of a circle, octagon, and square, and enclose an area of about four square miles, on

[1] Read before the Connecticut Academy of Arts and Sciences, Feb. 21, 1866.

the upper terrace between two branches of the Licking River. They were well described by Atwater, in 1820, who regarded them as works of defense;[1] and subsequently by Squier and Davis, who, however, considered them sacred enclosures.[2] Scattered over the same plain, and crowning the neighboring hills, are numerous tumuli, or mounds, evidently erected by the same people that built the larger works.

While on a geological excursion through the West, during the last autumn, the writer spent several days at Newark, examining these various monuments in company with George P. Russell, Esq., of Salem, Mass., who is well versed in everything relating to American antiquities. In the course of our investigations a sepulchral mound was opened, which proved to be in many respects the most interesting one of the kind yet examined. Mounds of this class received from Squier and Davis much less attention than the smaller "Alter Mounds," as the latter usually contain more relics of ancient art. These authors, moreover, examined none of those belonging to the Newark group of works, although the mounds in that vicinity appear to present some points of difference from those of other localities. For these reasons a more detailed account of our explorations will be given than would otherwise be necessary. The mound selected for examination was about two and a half miles south of Newark, on the farm of Mr. Thomas Taylor, and was known in the neighborhood as the "Taylor Mound." It was conical in form, about ten feet in height, and eighty in diameter at the base, these being about the average dimensions of the burial mounds in that vicinity. It was situated on the summit of a ridge, in the midst of a stately forest. On the mound itself several oak trees, two and a half to three feet in diameter, were growing, and near them were stumps of others, evidently of greater age. The mound stood quite alone, nearly half a mile from its nearest neighbor, and about three miles from the large earthworks already mentioned. In our explorations we were greatly assisted by Dr. J. N. Wilson, and Messrs. Dennis and Shrock, of Newark, and Charles W. Chandler, Esq., of Zanesville, who are all much interested in the local antiquities of that region.

An excavation about eight feet in diameter was first made from the apex of the mound, and after the surface soil was removed the earth was found to be remarkably compact, probably owing to its having been firmly trodden down when deposited. This earth was a light loam, quite different from the soil of the ridge itself, and its peculiar mottled appearance indicated that it had been brought to the spot in small quantities. In excavating

[1] Transactions American Antiquarian Soc., vol. i, p. 126.
[2] Smithsonian Contributions, vol. i, p. 67.

the first five feet, which was a slow and very laborious undertaking, nothing worthy of notice was observed except some traces of ashes, and pieces of charcoal and flint, scattered about at various depths. At five and a half feet below the surface, where the earth became less difficult to remove, a broken stone pipe was found, which had evidently been long in use. It was made of a very soft limestone containing fragments of small fossil shells, apparently Cretaceous species. No rock of precisely this kind is known to exist in Ohio. Pieces of a tube of the same material, and about an inch in diameter, were found near the pipe. The cavity was about two-thirds of an inch in diameter, and had been bored out with great regularity. Similar tubes have occasionally been found in mounds, but their use is not definitely known.

About seven feet from the top of the mound a thin white layer was observed, which extended over a horizontal surface of several square yards. Near the center of this space, and directly under the apex of the mound, a string of more than one hundred beads of native copper was found, and with it a few small bones of a child, about three years of age. The beads were strung on a twisted cord of coarse vegetable fibre, apparently the inner bark of a tree, and this had been preserved by salts of the copper, the antiseptic properties of which are well known. The position of the beads showed clearly that they had been wound two or three times around the neck of the child; and the bones themselves, (the neural arches of the cervical vertebræ, a clavicle, and a first rib), were precisely those which the beads would naturally come in contact with, when decomposition of the body ensued. The remains evidently owe their preservation to this fact, as they are all colored with carbonate of copper, and the other parts of the skeleton had entirely decayed. The position the body had occupied, however, was still clearly indicated by the darker color of the earth. The beads were about one-fourth of an inch long, and one-third in diameter, and no little skill had been displayed in their construction. They were evidently made, without the aid of fire, by hammering the metal in its original state; but the joints were so neatly fitted that in most cases it was very difficult to detect them. On the same cord, and arranged at regular intervals, were five shell beads, of the same diameter, but about twice as long as those of copper. All had apparently been well polished, and the necklace, when worn, must have formed a tasteful and striking ornament.[4]

[4] Native copper seems to have been the favorite material for ornaments among the mound-builders. The metal was, without doubt, derived originally from the Lake Superior deposits, although it may have been found in the drift. It was more probably taken directly from the deposits themselves, as they exhibit abundant evidence of ancient mining operations, which no one familiar with such matters would attribute to the more recent Indians.

About a foot below the remains just described, and a little east of the center of the mound, were two adult human skeletons, lying one above the other, and remarkably well preserved. The interment had evidently been performed with great care. The heads were toward the east, slightly higher than the feet, and the arms were carefully composed at the sides. A white stratum, similar in every respect to the one already mentioned, was here very distinct, and extended horizontally over a space of five or six yards, in the center of which the remains had been laid. The earth separated readily through this stratum, and an examination of the exposed surfaces showed that they were formed from two decayed layers of bark, on one of which the bodies had been placed, and the other covered over them. The smooth sides of the bark had thus come together, and the decomposition of the inner layers had produced the peculiar white substance, as a subsequent microscopic examination clearly indicated.[5] Directly above these skeletons was a layer of reddish earth, apparently a mixture of ashes and burned clay, which covered a surface of about a square yard. Near the middle of this space was a small pile of charred human bones, the remains of a skeleton which had been burned immediately over those just described. The fire had evidently been continued for some time, and then allowed to go out; when the fragments of bone and cinders that remained were scraped together, and covered with earth. All the bones were in small pieces, and most of them distorted by heat; but among them were found the lower extremity of a humerus, and some fragments of a fibula, which showed them to be human, and indicated an adult rather below the medium size. The two skeletons found beneath these remains were well formed, and of opposite sex. The ossification of the bones indicated that the female was about thirty years of age, and the male somewhat older. It is not impossible that these were husband and wife—the latter put to death and buried above the remains of her consort; and the charred bones may have been those of a human sacrifice, slain at the funeral ceremonies.[6] Near these skeletons was a small quantity of reddish brown powder, which proved on examination to be hematite. It was probably used as a paint.[7]

[5] This white layer, which was thought by Squier and Davis to be the remains of matting, is a characteristic feature in burial mounds. It has only been found where the interments were unquestionably those of mound builders.

[6] Among the ancient Mexicans and Peruvians, when a ruler or other person of high rank died, his wives and domestics were often put to death at the tomb, and in some instances the remains were burned.

[7] A larger quantity of the same substance was found in another mound near Newark. May not the "iron rust" discovered in the mound at Marietta, and regarded by some as proof that the mound-builders were acquainted with that metal, have been merely this substance? Implements of hematite were, indeed, found in the same mound.—*Transactions American Antiquarian Soc.*, vol. i, p. 168.

On continuing our excavations about a foot lower, and somewhat more to the eastward, a second pile of charred human bones was found resting on a layer of ashes, charcoal and burned clay. But one or two fragments of these remains could be identified as human, and these also indicated a small-sized adult. The incremation had apparently been performed in the same manner as in the previous instance. Immediately beneath the clay deposit a third white layer was observed, quite similar to that just described. In this layer was a male skeleton, not in so good a state of preservation as those already mentioned, although evidently belonging to an individual considerably older. In this case also the head was toward the east, and the burial had been carefully performed. Near this skeleton about a pint of white chaff was found, which appeared to belong to some of the native grasses. The form was still quite distinct, although nearly all the organic substance had disappeared. A few inches deeper, near the surface of the natural earth, several skeletons of various ages were met with, which had evidently been buried in a hurried manner. All were nearly or quite horizontal, but no layer of bark had been spread for their reception, and no care taken in regard to arrangement of limbs. These skeletons were in a tolerable state of preservation, some parts being quite perfect. A tibia and fibula, with most of the corresponding bones of a foot, were found quite by themselves, and well preserved.

Our excavations had now reached the original surface of the ridge, on which the mound was erected, and we were about to discontinue further researches, when the dark color of the earth at one point attracted attention, and an examination soon showed that a cist, or grave, had first been excavated in the soil, before the mound itself was commenced. This grave was under the eastern part of the elevation, about four feet from the center. It consisted of a simple excavation, in an east and west direction, about six feet long, three wide, and nearly two deep. In this grave were found parts of at least eight skeletons, which had evidently been thrown in carelessly,—most of them soon after death, but one or two not until the bones had become detached and weathered. Some of the bones were very well preserved, and indicated individuals of various ages. Two infants, about a year and eighteen months old respectively, were each represented by a single os illium, and bones of several other small children were found. One skull, apparently that of a boy about twelve years of age, was recovered in fragments, and this was the best preserved of any obtained in the mound. The skeleton of an aged woman of small stature was found resting on its side. It was bent together, and lay across the grave with its head towards the north. Some of the loose, human bones,

exhumed from the bottom of the grave, were evidently imperfect when thrown in. Among these was part of a large femur, which had been gnawed by some carnivorous animal. The marks of the teeth were sharply defined, and corresponded to those made by a dog or a wolf.

Quite a number of implements of various kinds were found with the human remains in this grave. Near its eastern end, where the detached bones had been buried, were nine lance and arrow-heads, nearly all of the same form, and somewhat rudely made of flint and chert. The material was probably obtained from "Flint ridge," a siliceous deposit of Carboniferous age, which crops out a few miles distant. These weapons are of peculiar interest, as it appears they are the first that have been discovered in a sepulchral mound, although many such have been carefully examined.[8] They show that the custom—so common among the Indians of this country—of burying with the dead their implements of war or the chase, obtained occasionally, at least, among the mound-builders. Not far from these weapons six small hand-axes were found, one of which was made of hematite, and the rest of compact greenstone, or diorite, the material often used by the Indians for similar articles. Two of these corresponded closely in form with the stone hand-axe figured by Squier and Davis as the only one then known from the mounds.[9] With these axes were found a small hatchet of hematite, a flint chisel, and a peculiar flint instrument, apparently used for scraping wood.

In the central part of the grave, near the aged female skeleton already alluded to, were a large number of bone implements, all exceedingly well preserved. Among these were five needles, or bodkins, from three to six inches in length, neatly made from the metatarsal bones of the common deer; and also a spatula, cut from an ulna, and probably used for moulding pottery. With these were found about a dozen peculiar implements formed from the antlers of the deer and elk. They are cylindrical in form, from three to eight inches in length, and an inch to an inch and a half in diameter. Most of these had both ends somewhat rounded, and perfectly smooth, as if they had either been long in use, or carefully polished. It is possible these implements were used for smoothing down the seams of skins or leather: they would, at least, be well adapted to such a purpose. A "whistle," made from a tooth of a young black bear, and several "spoons," cut out of the shells of river mussels, were also obtained near the same spot.

A vessel of coarse pottery was found near the western end of the grave, but, unfortunately, was broken in removing it. It

[8] Squier, Antiquities of New York, p. 331.
[9] Smithsonian Contributions, vol. i, fig. 110, p. 217.

was about five inches in its greatest diameter, six in height, and one-third of an inch in thickness. It was without ornament and rudely made of clay containing some sand and powdered quartz. It was filled with soft, black earth, the color being probably due to some animal or vegetable substance, which it contained when deposited in the grave. Fragments of a vase of similar material, but having the top ornamented, were found in another part of the mound. Neither of these vessels were superior, in any respect, to the pottery manufactured by the Indians.

Near the bottom of the mound, and especially in the grave, were various animal bones, most of them in an excellent state of preservation. Many of these belonged to the common deer, and nearly all the hollow bones had been skillfully split open lengthwise,—probably for the purpose of extracting the marrow,—a common custom among rude nations. Some of these remains of the deer indicated individuals of a size seldom attained by the species at the present time. Beside one of the skeletons in the grave, and evidently deposited with it, were several bones of the gray rabbit. This renders it not unlikely that the mound-builders used this animal for food,—a point of some interest, as the inhabitants of Europe in the stone age are supposed to have been prevented from eating the hare, by the same superstition that prevailed among the ancient Britons, and is still observed among the Laplanders.[10]

Some of the animal remains in the mound, although well preserved, were in too small fragments to admit of accurate determination. Characteristic specimens, however, were obtained of those in the following list:

Cervus Canadensis, Erxl., (elk).
Cervus Virginianus, Bodd., (common deer).
Ursus Americanus, Pallas, (black bear).
Canis latrans? Say, (prairie wolf).
Lepus sylvaticus, Bach., (gray rabbit).
Arctomys monax, Gm., (woodchuck).
Unio alatus, Say, (river mussel).

It will be observed that these are all existing species, and, with one or two exceptions, are still living in Ohio—a fact of some importance in its relation to the antiquity of the mounds. The discovery of these remains under such circumstances shows, moreover, that the mound-builders depended, to some extent, at least, on the chase for subsistence. If, however, they were a stationary and agricultural people, as is generally supposed, we should expect to find in the mounds, the remains of domestic, rather than of wild, animals, but none of these have yet been discovered. This may be owing to the fact that comparatively

[10] Lyell, Antiquity of Man, p. 24. London. 1868.

little attention has hitherto been paid to the animal remains, and other objects of natural history found in the mounds, although a careful study of these would undoubtedly throw much light upon the mode of life of the mound-builders.[11]

The excellent state of preservation of the various skeletons in this mound is remarkable, and has probably never been equalled in the hundreds that have hitherto been examined. The remains of undoubted mound-builders have almost invariably been found so much decayed that it was impossible to recover a single bone entire.[12] The preservation in this case was doubtless due in part to the excessive compactness of the earth above the remains, but mainly to the fact that the mound stood on an elevation, where moisture could not accumulate. The skeletons in the lower part of the mound were not so well preserved as those higher up, probably because the original soil of the ridge naturally retained more moisture than the earth above it. There may have been, moreover, a considerable interval between the irregular burials, and those that followed, and thus some of the skeletons commenced to decay before the mound was completed. The interval, however, could not have been of very long duration, as no perceptible deposit of vegetable matter was formed over the small mound then existing. The same may be said of the intervals between the regular interments, and also of the subsequent period preceding the final completion of the mound. It should, perhaps, be remarked before proceeding further, that this mound had evidently never been disturbed by the Indians, and that all the human remains and other objects found in it were undoubtedly deposited there by its builders. This will readily be admitted by every one familiar with the subject, as the last interment was at least seven feet below the surface, directly under the apex of the mound, and the white layers—infallible indications of regular burials of the mound-builders—all extended over the grave, and remained undisturbed.[13]

The skeletons found in this mound were of medium size, somewhat smaller than the average of those of the Indians still

[11] The animal remains found near the Swiss lake habitations, show conclusively that the earliest inhabitants of those settlements were hunters, who subsisted chiefly on wild animals: at a later period, however, during the change to a pastoral state, domestic animals were gradually substituted as an article of food.—*Rütimeyer, Fauna der Pfahlbauten der Schweitz.* Basel, 1861.

[12] Squier and Davis regard this fact as evidence of the great antiquity of the mounds, as in England, where the moist climate is much less favorable for preserving such remains, perfect skeletons of the ancient Britons have been found, although known to have been buried at least 1800 years.—*Smithsonian Contributions*, vol. i, p. 168.

[13] It is well known that the modern Indians occasionally buried their dead in the mounds, but invariably near the surface; the position of such remains, and especially the manner of their interment clearly distinguish them from the original deposits of the mound-builders.

living in this country. The bones were certainly not stouter than those of Indians of the same size, although this has been regarded as a characteristic of the remains of the mound-builders. All the skulls in the mound were broken—in one instance apparently before burial—and most of them so much decayed that no attempt was made to preserve them. Two, however, were recovered with the more important parts but little injured. Both were of small size, and showed the vertical occiput, prominent vertex, and large interparietal diameter, so characteristic of crania belonging to the American race. In other respects there was nothing of special interest in their conformation. With a single exception, all the human teeth observed were perfectly sound. The teeth of all the adult skeletons were much worn, those of aged individuals usually to a remarkable degree. The manner in which these were worn away is peculiarly interesting, as it indicates that the mound-builders, like the ancient Egyptians, and the Danes of the stone age, did not, in eating, use the incisive teeth for cutting, as modern nations do. This is evident from the fact that the worn incisors are all truncated in the same plane with the coronal surfaces of the molars, showing that the upper front teeth impinge directly on the summits of those below, instead of lapping over them. This peculiarity may be seen in the teeth of Egyptian mummies, as was first pointed out by Cuvier.[14]

All the bones in this mound, animal as well as human, were very light, and many of them exceedingly brittle. They adhere strongly to the tongue, but application of hydrochloric acid shows that they still retain a considerable portion of the cartilage. Some of the more fragile bones, which showed a tendency to crumble on exposure to the air, were readily preserved by immersing them in spermaceti melted in boiling water, a new method, used by Prof. Lartet and other French paleontologists, and admirably adapted to such a purpose.

There are several points connected with this mound which deserve especial notice, as they appear to throw some additional light upon the customs of the mound-builders, particularly their modes of burial, and funeral ceremonies. One of the most remarkable features in the mound was the large number of skeletons it contained. With one or two exceptions, none of the burial mounds hitherto examined have contained more than a single skeleton which unquestionably belonged to the mound-builders, while in this instance parts of at least seventeen were exhumed. The number of small children represented among these remains is also worthy of notice, as it indicates for this particular case a rate of infant mortality (about thirty-three per

[14] Leçons d'Anatomie comparée, tome ii, p. 105. Bruxelles, 1838.

cent) which is much higher than some have supposed ever existed among rude nations. Another point of special interest in this mound is the evidence it affords that the regular method of burial among the mound-builders was sometimes omitted, and the remains interred in a hurried and careless manner. This was the case with eleven of the skeletons exhumed in the course of our explorations, a remarkable fact, which appears to be without a precedent in the experience of previous investigators. It should be mentioned in this connection that nearly all of these remains were those of women and children. Their hurried and careless burial might seem to indicate a want of respect on the part of their surviving friends, were there not ample evidence to prove that reverence for the dead was a prominent characteristic of the mound-builders. It is not unlikely that in this instance some unusual cause, such as pestilence or war, may have made a hasty interment necessary. The various implements and remains of animals found with these skeletons also deserve notice, as they far exceed in number and variety any hitherto discovered in a single mound. They prove, moreover, that, if in this instance the rites of regular burial were denied the departed, their supposed future wants were amply provided for. The contents of one part of the cist (which is itself a very unusual accompaniment of a mound) appears to indicate that the remains of those who died at a distance from home were collected for burial, sometimes long after death. The interesting discovery of weapons, which were found with these detached bones, would seem to imply that in this case the remains and weapons of a hunter or warrior of distinction, recovered after long exposure, had been buried together.[15]

The last three interments in this mound were performed with great care, as already stated, and in strict accordance with the usual custom of the mound-builders. The only point of particular interest in regard to them is the connection which appears to exist between some of the skeletons and the charred human bones found above them. Similar deposits of partially burned bones, supposed to be human, have in one or two instances been observed on the altars of sacrificial mounds, and occasionally in mounds devoted to sepulture, but their connection with the human remains buried in the latter, if indeed any existed, appears to have been overlooked. Our explorations, which were very carefully and systematically conducted, clearly demonstrated that in these instances the incremation had taken place directly over the tomb, and evidently before the regular interment was completed: taking these facts in connection with what the researches of other investigators have made known

[15] A similar custom still prevails among some tribes of western Indians.

concerning the superstitious rites of this mysterious people, it seems natural to conclude that in each of these cases a human victim was sacrificed as part of the funeral ceremonies, doubtless as a special tribute of respect to a person of distinction.

All the skeletons in this mound, except one, appeared to have been buried in a horizontal position with the face upwards. The exception was the skeleton of the aged female found in the grave, which lay on its side; but this may have been owing to the fact that the body had been bent together, perhaps in consequence of age. The skeletons which had received a regular interment all had their heads toward the east, but no such definite position has been noticed in the remains found in other mounds. As the grave had the same direction, this can hardly have been unintentional, although it may have been determined by the position of the ridge upon which the mound stood. The layer of charcoal, not unfrequently found in sepulchral mounds, was wanting in this instance, as was also the evidence, usually afforded by the same substance, that the fire, which consumed the human remains, had been suddenly extinguished by a covering of earth. Possibly the former, as well as other objects of interest, were contained in the outer portion of the mound, which was not examined, although usually everything deposited by the mound-builders was placed near the center; and hence our explorations were chiefly confined to that part.

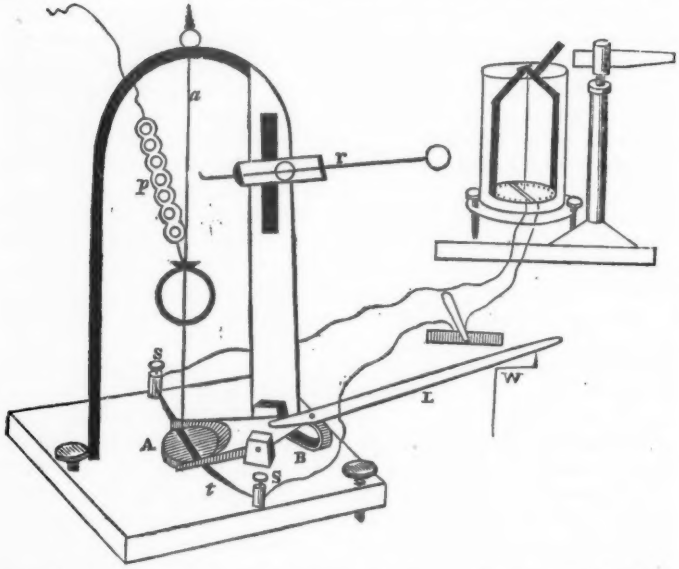
Such is a brief and incomplete description of one of the ancient mounds of the West, of which at least ten thousand are known to exist in the single state of Ohio, and countless numbers elsewhere in the valleys of the Mississippi and its tributaries. These structures are the only remaining memorials of a race whose history has been buried with them, and from these alone can we hope to learn who this people were, and whence they came. The Indians of this country, although retaining no tradition of this more ancient population, regarded their works with great veneration; but the present possessors of the soil have, in general, little of this feeling, and hence hundreds of these monuments of the past are annually swept away by the plow, and their contents irretrievably lost. A few pioneers in American archæology have, indeed, rescued much that is valuable, but the work is hardly commenced; and a careful and systematic investigation of these various monuments would not only add greatly to our knowledge of this interesting people, but doubtless also help to solve the question of the antiquity of man on this continent, and, perhaps, that more important one of the unity of the human race.

New Haven, Ct., Feb. 1866.

ART. II.—*On the production of Thermo-electric currents by percussion;* by O. N. ROOD, Prof. of Physics in Columbia College.

THE production of thermo-electric currents by *friction* was observed by P. Erman in 1845,[1] but I do not know that the subject of the present article has ever been examined with any care.

For the purpose of studying the thermo-electric currents produced by percussion, the apparatus represented in the figure



was devised: it consists of a vertical brass wire *a*, stretched in the manner indicated; on it a brass ball weighing 17 oz. slides freely, the wire passing through one of its diameters. The ball can be raised to the height of from 1 to 5 inches by a string connected with the brass plate *p*. At the proper moment the ball can be allowed to fall: this is effected by passing the bent end of the rod *r* through one of the five holes in the brass plate *p*; by turning this rod through an angle of 90° the ball is set free and falls. The rod is fastened at such a height that when its bent end is in the highest of the five holes, the distance between the lower surface of the ball and the anvil below, is one inch. The holes in brass plate again are exactly one inch apart, so that the experimenter can easily, without altering the appa-

[1] Arch. de l'El., v. 477; Inst. No. 614, p. 355.

ratus, obtain at will, a fall of 1, 2, 3, 4 or 5 inches successively, by raising the ball by the string, and using in turn each of the five holes in the brass plate. By this means the production of accidental thermo-electric currents from the heat of the hands is avoided, as the string and bent rod enable the observer to make the necessary adjustments from some distance.

The ball falls on a thermo-electric couple *t*, consisting of a compound wire of German silver and iron soldered together, or better, of a compound *plate* of the same metals, the juncture being soldered, as when *plates* are used, the couple suffers but little injury from the repeated falls of the ball. In the selection of these two metals for the couple, a suggestion of Poggendorff is followed, who showed that they give a strong current when their juncture is heated. The couple is so arranged that the ball strikes just on the juncture of the two metals, and there by means of the heat developed, produces a thermo-electric current. The juncture of the two metals was generally insulated by silk, &c., to prevent the heat from being immediately conducted off. The two farther ends of the couple were fastened by the binding screws *s s*, which were in metallic connection with a delicate galvanometer.

Below the couple is the brass anvil A.

A certain amount of heat is developed at the junction of the couple by a given fall of the ball; if now the couple were left in contact with the ball and anvil after the fall, this heat would be rapidly conducted away; it therefore became necessary to contrive, first, an apparatus for raising the ball instantly after its fall out of contact with the couple, and second, some arrangement for raising the couple at the same instant out of contact with the anvil. The former of these ends is accomplished by the lever L, the shorter arm of which is cut out so that when it is pressed down by the spring B, it rests on the anvil over the couple, and is out of the reach of the falling ball. As the sound of the concussion is heard, the long end of the lever is quickly pressed down, and fastened by turning the bent wire at *w*. The lever thus raises the ball $\frac{1}{2}$ inch above the couple, and the latter itself acting at the same instant as a spring, raises itself by its own elasticity above the anvil. The wires from the binding screws were connected with an apparatus for breaking the circuit, in which small cups of mercury were used. This portion of the apparatus was placed on a table; the galvanometer, however, on a shelf attached to the wall of the room with brass nails, it being found that iron nails exercised a considerable effect on the astatic needle. When thus arranged, and observed with the telescope, the steadiness of the needle was not sensibly affected by a person walking about the room.

The upper needle of the galvanometer was provided with a very fine glass rod, which served as an index, the breadth of the rod being only half of that of the divisions on the galvanometer circle. The end of the glass rod was blackened to render it plainly visible. Directly over the needle, a mirror silvered by Liebig's process was placed at an angle of 45°; the index was observed with aid of this mirror and a small telescope magnifying five diameters; in this manner $\frac{1}{10}$° could be estimated.

The falling apparatus was enclosed by wooden screens, also the apparatus for breaking the circuit and the galvanometer. If these precautions are neglected accidental currents are constantly circulating in the wires employed, and no reliable results can be obtained. It is farther necessary after exchanging the couple or handling the binding screws, to allow the apparatus to remain at rest for two or three hours, so that the currents may subside; it is also necessary to select for observation, those intervals of time when the temperature of the room is constant. I may remark, finally, that in spite of all these precautions it is rarely the case that very feeble and nearly constant accidental currents are wholly absent.

The galvanometer was made by Duboscq; after balancing the magnetism of the needles it was found that the copper wire of the coil was so magnetic that the needles took up a position 30°–35° on either side of the zero point. I re-wound the frame with American wire, when the needle readily returned to the true zero; upon, however, bringing the two needles very nearly into the same plane, and carrying forward their astasie, the same difficulty was again experienced, when another sample of American wire was tried with a result which was but little better.

All of these samples when tested in the apparatus used for experiments on diamagnetism, were evidently magnetic, the French sample being strongly so. The difficulty was evaded by bending the needles slightly out of the true plane, when they took up a position nearly east and west, and returned with certainty to the true zero. In this state of inferior sensitiveness one simple oscillation consumed 18 seconds. There were sufficient indications to show that owing to the magnetism of the coil the needle was more sensitive to currents when standing at 10°–15° than when at 0°; it accordingly became necessary to calibrate the instrument with care. This was done by one of the methods described by Melloni and quoted by Tyndall, (Heat considered as a mode of motion, p. 370).

For degrees under 10° the constant currents employed in the calibration were produced by a small thermo-electric pile with one of its faces turned toward the exterior colder wall of the room, while the other face was directed toward an interior wall.

These, as it were natural sources of heat gave very constant currents, and by partially closing one of the caps of the pile, any desired deviation between 0° and 10° could readily be obtained.

It was found that for about 6° the deviation of the needle was directly proportional to the strength of the current; for degrees beyond this, it was necessary to construct a curve embodying the corrections obtained experimentally. The ratio between the first and final deviation up to 30° was also obtained; it was constant for 6°. These latter determinations were important, as after the first deviation the needle, owing to conduction in the couple, slowly sinks to 0°, and only then comes to rest. I was not able to measure with exactitude the time required for currents produced by falls of the ball from different distances to subside, the imperfect results obtained showed that it varied between $1\frac{1}{2}$ minutes up to $3\frac{1}{2}$ minutes, according to the distance fallen by the ball. It having been found then in the calibration experiments, that the force of the current was proportional to the deviation up to 6°, and farther, that the first deviation was proportional to the final deviation for the same number of degrees, in the results given below, where the first deviation was below 6°, the observations actually obtained and unreduced will be given, but where the first deviation exceeded 6° the reduced results will be found.

As the total amount of heat produced by the fall of a body is divided between the falling body and that arresting its motion, it is evident that if the mass of the latter be small compared with that of the falling body, its *temperature* will, owing to this fact, be correspondingly high; and if the arresting body be a thermo-electric element of small mass, a proportionately large deviation of the galvanometer needle will be produced. If, however, the couple at the moment of the percussion and afterwards, be allowed to be in metallic contact with the metallic ball, the temperature of the couple will by conduction be rapidly reduced to that of the metallic ball, so that the deviation of the needle will be very small, and the phenomena complicated. To illustrate this I give, in table 1, the small and irregular deviations which were produced under these circumstances; the ball, couple, and anvil all remaining in metallic contact after the fall.

TABLE 1.

Distance fallen,	1 in.	2 in.	3 in.	4 in.	5 in.
Deviations,	$\frac{2}{10}$°	$\frac{2}{10}$°	$\frac{3}{10}$°	$\frac{7}{10}$°	$\frac{4}{10}$°
	$\frac{1}{10}$	$\frac{2}{10}$	$\frac{3}{10}$	$\frac{3}{10}$	$\frac{5}{10}$
	0	0	$\frac{1}{10}$	$\frac{2}{10}$	0

In table 1, a newly prepared compound plate similar to that used in table 4 was employed.

To avoid the effects of conduction external to the couple, a number of insulating substances were tried, which gave more or less constant results.

1. Thin card board or plates of mica placed above and below the couple gave irregular results.

2. Two thicknesses of dried bladder, placed above and below the couple, gave somewhat better results.

3. Four thicknesses of heavy woven silk were also used for the same purpose.

4. The best results were, however, obtained by using heavy woven silk, which was spread over with a coating of yellow wax, and then wrapt around the couple at the juncture. This insulating substance after being used for some time so as to become compacted, gave results which were about as constant as could be expected under the circumstances.

Below are results obtained in these several ways:

TABLE 2.— *With two skins above and below.*

Distance fallen,	1 in.	2 in.	3 in.	4 in.
First unreduced deviations,	1·5°	2·2°	3·0°	5·8°
	1·4	2·3	4·3	4·1
	1·8	2·5	3·0	4·4
	1·2	3·5	3·4	5·9
	1·4	3·0	3·5	6·0
	1·2	3·5	3·7	5·0
	1·1	2·4	4·1	5·8
	1·1	2·2	3·4	4·9
Average,	1·3	2·7	3·55	5·2

In this and in all the other tables, the order of the experiments was across the page, from left to right, and not down the single columns.

Table No. 3, contains results obtained with four layers of plain silk above and below the couple.

TABLE 3.

Distances fallen,	1 in.	2 in.	3 in.	4 in.
First unreduced deviations,	1·6°	3·4°	3·7°	6·1°
	1·4	2·7	3·9	5·4
	1·6	3·5	4·1	6·0
	1·7	2·7	4·2	6·0
	1·5	2·6	4·3	6·0
	1·5	2·8	5·0	6·5
	1·4	2·6	4·7	6·0
	1·4	2·6	4·3	6·9
Average,	1·5	3·0	4·5	6·0

The results given in tables 2 and 3, were obtained by using a compound *wire* of German silver and iron with a diameter of 9 of a millimeter; the juncture was bound with a little fine iron wire and soldered. This form of couple was found to lose its shape by the repeated blows; it also finally cut the insulating substance, so that in all the following experiments *plates* of the

same metals soldered together were used; the form of these plates remained nearly unaltered.

Accordingly, to obtain the results given in 4 and 5, a compound plate of this kind was used; the breadth of the plate was 7 millimeters, length 150 millimeters, thickness of iron and of German silver being about ·2 of a millimeter.

The plate in table 4 was wound with four layers of heavy plain silk.

TABLE 4.

Distance fallen,	1 in.	2 in.	3 in.	4 in.	5 in.
First unreduced deviations,	1·6°	2·6°	3·8°	4·0°	4·9°
	1·4	2·3	3·4	3·9	4·6
	1·3	2·2	3·1	3·9	4·7
	1·3	2·4	3·4	4·0	4·5
	1·3	2·2	3·5	3·8	4·5
Average,	1·38	2·3	3·4	3·7	4·6

Table 5 gives results when 4 layers of *waxed* silk were used with the same couple.

TABLE 5.

Distance fallen,	1 in.	2 in.	3 in.	4 in.	5 in.
First unreduced deviations,	1·5°	3·1°	5·0°	6·4°	8·9°
	1·5	3·0	4·8	6·3	8·7
	1·6	2·9	4·8	6·2	8·2
	1·5	2·9	4·2	5·6	8·3
	1·4	2·8	4·2	5·7	8·0
Average,	1·5	2·94	4·6	6·04	8·4
Reduced average,	1·07	2·1	3·28	4·3	6·0

It will be observed that in tables 2, 3 and 5 the result is more or less perfectly indicated that the force of the current is proportional to the distance the ball falls through, or in other words to the square of its velocity at the moment of impact.

Effect of allowing the ball to remain in contact with insulated couple after the impact.

The results given in table 6 were obtained directly after those given in table 5, everything remaining unaltered except that the ball was not raised out of contact with the couple.

TABLE 6.

Distance fallen,	1 in.	2 in.	3 in.	4 in.	5 in.
First unreduced deviation,	2·0°	2·5°	3·6°	4·2°	5·8°
	1·9	2·6	3·1	4·0	5·7
	1·7	2·3	3·2	4·0	5·4
	1·6	2·3	3·0	3·6	5·1
Average,	1·8	2·42	3·22	3·95	5·5

The extent to which the heat generated is thus conducted away from the couple is very noticeable in the last three columns, but it is a little remarkable that the deviations in the first column are higher than in table 5; a corresponding result obtained

with a *narrow* couple is given below in table 8. To ascertain that the plate had not been altered, experiments were made with it afterward, the ball being lifted.

To find out whether any peculiar influence was exercised by the mass of the couple within small limits, the above mentioned plate was now cut down, till its breadth was 3 millimeters. It was covered with waxed silk and the following results obtained:

TABLE 7.

Distance fallen,	1 in.	2 in.	3 in.	4 in.	5 in.
Reduced deviations,	1·50°	3·28°	4·80°	6·46°	7·20°
	1·35	2·42	4·77	6·10	7·10
	1·20	2·42	3·50	4·90	6·38
	1·14	2·07	3·00	5·00	7·00
	1·07	2·01	3·00	4·90	6·46
	1·14	1·90	3·20	5·00	6·20
Average,	1·23	2·35	3·71	5·39	6·72

To compare the temperature here developed with what was produced in the broad plate before it was cut down, I give below the reduced deviation of the broad plate taken from table 5:

	1 in.	2 in.	3 in.	4 in.
Reduced deviation of narrow plate,	1·23	2·35	3·71	5·39
" " " broad "	1·07	2·1	3·28	4·30
Difference,	·16	·25	·43	1·09

The narrow plate used in table 7 being employed and arranged exactly as before, the ball was allowed after its fall to remain in contact with the insulated couple.

TABLE 8.

Distance fallen,	1 in.	2 in.	3 in.	4 in.	5 in.
Unreduced deviations,	2·4°	3·0°	3·7°	3·9°	5·6°
	2·5	3·1	3·8	3·9	5·9
	2·5	3·0	3·4	3·5	5·2
	2·6	3·1	3·7	3·9	5·9
Average,	2·5	3·05	3·6	3·8	5·65
Reduced average,	1·79	2·17	2·57	2·7	4·0

Effect of the first twenty, &c. falls on the newly prepared plate.

When the couple is wound with plain or with waxed silk, and subjected to the action of the falling body, the first 15–20 deviations of the needle are much larger than any above given with the successive falls as the silk becomes compacted, the deviations decrease in size, reach a minimum, and remain about as constant as shown in the tables. The results so far given then, except, of course, in case of table 1, were obtained after this point had been approximately reached. I give below, as a sample, the first set of deviations obtained directly after winding with waxed silk the couple used in table 7. The ball was lifted in the usual way.

Distance fallen being 5 in., the reduced deviations are given: 23·5°, 17·2°, 16·3°, 13·8°, 12·4°, 11·6°, 10·1°, 8·5°, 9·1°, 9·1°, 8·6°, 8·4°, 8·1°, 7·9°, 8·4°, 8·4°, 7·85°, 7·4°, 7·5°, 6·6°, 7·2°, 7°, 6·8°.

A similar action was observed with unwaxed silk. This might be accounted for by saying that the mass of silk and wax becoming compacted is then a better conductor of heat than before, and that the temperature of the couple is thus lowered by the short but necessary contact with the ball; but the comparatively small effect which is produced even by continued contact with the ball shown in tables 6 and 8 prove that this supposition is untenable.

The larger deviation must then be attributed to the sliding of the particles of silk and wax over themselves, this taking place to a much greater extent in the first twenty falls than afterward. After the minimum point has been reached, if the couple is laid bare and rewound, the same large deviations are obtained, showing that they are not due to an alteration in the couple itself.

Finally, it is remarkable that a much smaller mechanical force applied directly to the couple in the shape of friction, produces a disproportionately large deviation; thus drawing the wooden end of a lead-pencil once over the naked junction with a force less than would be generated by the ball falling 1 inch gave a deviation of 18–25°.

It is hardly necessary to add, that the deviation of the needle was in all cases in the same direction as though heat had been applied to the juncture of the thermo-electric couple.

New York, Feb. 22, 1866.

ART. III.—*A Classification of Mollusca, based on the "Principle of Cephalization;"* by EDWARD S. MORSE.[1]—With a plate.

AFTER becoming acquainted with the perfect unity of plan in the Radiata and the connected series of homologies, running through the whole branch, (as demonstrated by Prof. Agassiz in his private lectures) my interest was excited to discover, if possible, a like symmetry of development in the Mollusca. Finding the universality of vertebration among the Vertebrata, of articulation among the Articulata, and similarly of radiation among the Radiata, I could not but believe that in the Mollusca some plan lay hidden, which, when unfolded, would as definitely convey their type, and unite them all, as in the other branches.

[1] Proc. of Essex Institute, iv, p. 162.

It is not enough to call them soft bodied animals; for in considering their shell as a part of their organization, we have among them many of the hardest animals known, and we also have an equal number of soft bodied animals in the other branches. Their bilaterality, as expressing anything definite, is an equally unsatisfactory character. Prof. Huxley has given an archetype, or common plan of the Mollusca, as he conceives it, with many truthful homologies, in the article "Mollusca," English Cyclopedia, vol. iii, p. 855. In his figure of the archetype, however, which is bilaterally symmetrical, we have details of structure only.

Prof. Agassiz in his "Methods of Study in Natural History" also suggests his idea of the plan, or structure, when he says, p. 34, "Right and left, have the preponderance over the other diameters of the body," and says furthermore, that collectors unconsciously recognize this in the arrangement of their collections. "They instinctively give them the position best calculated to display their distinctive characteristics, and to accomplish this they necessarily place them in such a manner as to show their sides." This can refer only to the Lamellibranchs, and their shells are displayed on the sides, because they naturally fall in that position. This lateral preponderance of structure only obtains among the Lamellibranchs. All Brachiopods are displayed from the dorsal or ventral valve. Also the Gasteropods, particularly the flat forms like Patella, Chiton, etc., and the Nudibranchs as well, while in the figures of the naked Cephalopods we most usually have a dorsal view.

Though Prof. Agassiz speaks of radiation as characterizing the Radiates, and similarly of articulation and vertebration as characterizing the Articulates and Vertebrates, yet Mollusks are spoken of as first introducing the character of bilaterality, or division of parts along a longitudinal axis, that prevails throughout the Animal Kingdom, with the exception of the Radiates. This then can be no restricted definition for the Mollusca, since it pervades the two higher branches; and who will deny the evidence of bilaterality among the Radiates, the higher Echinoderms for instance, as Clypeastroids and Spatangoids, where we have as good a definition of a longitudinal axis as we obtain in many Mollusks. Even among the Polyps, as in the Actinaria, the antero-posterior axis is clearly expressed in the undue prominence of the primary radii.

Prof. Dana has been the first to publicly announce the plan of Mollusca, when he says, "The structure essentially a soft, fleshy bag, containing the stomach and viscera, without a radiate structure, and without articulations."[1]

[1] Dana's Manual of Geology, p. 148.

As far back as 1855 he presented this thought in his lectures at Yale College.

In the year 1862 Mr. Alpheus Hyatt had independently worked out a similar result, and has already in MSS. notes, the necessary data demonstrating the same.[1]

Mr. Hyatt also proposes the name Saccata as more fully and truthfully expressing the type, than the unmeaning word Mollusca. This name not only expresses the Plan, but is equivalent to the titles Vertebrata, Articulata, and Radiata, and is in no way a qualitative appellation.

Objecting as all must to the introduction of a new name, still one so appropriate as that proposed by Mr. Hyatt, in lieu of one that has no relation to the Branch, except its traditional use, is certainly worthy of consideration, as it so clearly indicates what is believed to be the fundamental idea in the Branch, that of the Sac. * * *

In the following considerations, all preconceived ideas regarding the relative positions of the dorso-ventral, and antero-posterior diameters of the animal must be laid aside, and the essential structure of the animal, if rightly understood, must be our guide. The gradual morphological changes of the contents of the sac, and all other relations, are based on the principle of Cephalization. In the plate presented (Series I) I have given a typical figure of the six prominent groups of the Saccata; namely, Polyzoa, Brachiopoda, Tunicata, Lamellibranchiata, Gasteropoda, and Cephalopoda.

For obvious reasons, only the intestine, head, and pedal ganglia within the sac are represented. These six figures are placed in their normal position, anterior pole downward, the dorsal region is turned to the left. Commencing with the Polyzoa, (Series I, P) we have the sac closed, while the mouth and anus terminate close together at the posterior pole of the sac; the mouth occupying the extreme posterior position, and by a dorsal bend of the intestine upon itself, terminating dorsally. The nerve mass is found between the oral and anal openings. In this class the mouth and anus have the power of protrusion from the sac. In the three lower orders, Cyclostomata, Ctenostomata, and Cheilostomata, the polyzoon, when completely evaginated, presents no fold or inversion of the sac, while in the higher group Phylactolæmata, there is a partial and permanent inversion of the sac under like conditions.

[1] Mr. Hyatt has relinquished all ideas of publishing on this subject, since becoming aware that I was to do the same. During the preparation of these pages, I enjoyed his companionship, and many of the points herein stated were fully and freely discussed between us, and to him I am indebted not only for the privilege of announcing his proposed name, Saccata, but for the suggestion of certain points to be hereinafter mentioned.

This latter group, combining the permanent inversion of the sac-walls with the lophophoric arms, is the first approach to the Brachiopoda. No organ corresponding to a heart has yet been discovered. In the Brachiopoda (Series I, B) we have a permanent invagination of the sac, and the mouth, as in Terebratula, already occupies a position some distance from the posterior edges of the overlapping shells, and the brachial coils permanently occupy the space thus made.[4]

We have in this group a dorsal flexure of the intestine, and a tendency to terminate as in the polyzoa. In Lingula it terminates posteriorly and at one side. By the permanent inversion of the sac, the mouth makes a great advance toward the anterior pole. In Terebratula, Waldheimia, and allied genera, where the sac is very short and swollen, and the brachial coils very large, the viscera are crushed to the front, and the intestine, which is short and simple, is nearly bent upon itself, though still occupying a median line. In Lingula, where we have a very long and flat sac, the intestine is long, and has ample room for convolutions, but the anus, instead of terminating in a line with the mouth, is thrown to one side, in consequence of this excessive flatness of the sac. The heart will be found on the outer bend of the intestine and actually on the ventral side; the nerve occupying its homological position.

(The manner in which I view the Brachiopoda, if true, will entirely reverse the accepted poles of their structure. What has been considered as dorsal, is here regarded as ventral, and what has been considered as anterior is here regarded as posterior. Further remarks on this will be made hereafter).

Thus far the balance of structure has been thrown to the posterior pole of the sac, and though we see a cephalization, or concentration of the muscular system and viscera, toward the anterior pole in Brachiopoda, yet that pole being essentially closed, we have no function manifested at that end, except the degradational one of adhesion. In the Tunicata (Series I, T) we have, through continued cephalization, the mouth thrown to the bottom of the sac, or nearer the anterior end, and now the anus terminates behind the mouth, and posteriorly.

The heart has also followed the intestine in its rotation and becomes anterior, and partially dorsal. The nerve mass is still posterior and occupies a position between the two openings as in Polyzoa. We have commencing in this group, the Tunicata, that erratic bending of intestine, and varied position in its anal termination, that is witnessed higher up in the scale, and though

[4] "Terebratulina caput-serpentes, and Crania anomala, projected their cirri beyond the margin of the open valves, and moved them as the Polyzoa move their oral tenticles, but in no instance were the arms extended." Woodward's Treatise, p. 466.

apparently governed by no law, we can yet trace the progressive movements toward a normal condition, by comparing Appendicularia, one of the lowest forms of the Tunicates, and representing the larval condition of their class. In this form the intestine has a ventral flexure, and terminates on the ventral side. In Pyrosoma it makes an abrupt bend toward the anterior dorsal region, and terminates anteriorly. In Salpa it terminates dorsally, on a line with the mouth, though still anteriorly. In Botryllus it creeps up, and terminates nearer the posterior pole of the sac, though still dorsally. We have in this genus, and other compound Ascidians, the excurrent orifices of several individuals coalescing, forming a common cloaca for a community. The dorsal flexure is distinctly seen in Clavellina borealis. In these three classes; namely, Polyzoa, Brachiopoda, and Tunicata, the sac is essentially closed at the anterior end, and consequently the mouth opens toward the posterior end, and with few exceptions all are attached by the anterior end.

This makes a natural division, corresponding to the Molluscoidea of Milne-Edwards, the Anthoid Mollusks of Dana, and a portion of the neural division of Huxley. In the Lamellibranchiata (Series I, L) we have the sac opening anteriorly, and the mouth permanently occupying the anterior region, though in the lower forms pointing posteriorly, and in all cases the tentacular lobes pointing in that direction, and the mouth bent downward (ventrally), and partially obstructed by the anterior adductor, or by the undivided mantle. The gradual enlargement of the anterior opening is clearly seen, where in the Gastrochœnidæ, we have first a minute orifice for the passage of an immature foot, or metapodium, this opening gradually enlarging in different genera, until in the Unionidæ we have the sac almost completely separated, except dorsally. It will be noticed that the anterior opening is also ventral, or nearly so, in the lower forms. In Gasteropoda (Series I, G) the posterior end of the sac becomes essentially closed, and the ambient fluid now finds access to the gills through the anterior (though partially ventral) portion of the sac, while with Cephalopoda (Series I, C) the opening is all anterior. Thus far we have traced the gradual cephalization of the contents of the sac, and of the sac itself. The dotted lines X X, running through the oral opening of each figure in Series I of Plate, show the gradual advance of this opening from the lower to the higher classes. In the lowest class all the display of structure, with the oral and anal openings, lies at the posterior pole of the sac. In this highest class, all this display of structure lies at the anterior pole. Advancing from the Polyzoa, by the gradual advance of the mouth, the posterior pole becomes less prominent. Even when the sac opens anteriorly, as in the Lamellibranchiata,

the posterior end of the sac remains open, and the mouth, partially inclined that way, receives its food from that end; the food being conducted to the mouth by ciliary motion as in the three lower classes. The nature of their food is also identical, being of an infusorial character, and as such it is obvious that masticating organs, or biting plates, such as we find in the two higher classes, are not needed.

So long also as the posterior end of the sac remains open, the anus terminates at that end; when this opening becomes closed, as in the higher classes, the anus seeks an outlet through the anterior opening, and the mouth, that before received its food from the posterior end of the sac and by ciliary motion, now distinctly points the opposite way, and is furnished with the proper organs to procure food, the nature of which requires separation and trituration.

In nearly all the foregoing homologies, and also the position in which I place the Tunicate sac, I am sustained by the writings of eminent naturalists. With the Brachiopoda, however, my views completely reverse the accepted poles of the body, though, even here, according to "Woodward's Treatise on Mollusca," page 204, Forskahl and Lamarck "compared *Hyalea* with *Terebratula;* but they made the ventral plate of one answer to the dorsal valve of the other, and the anterior cephalic orifice of the pteropodous shell correspond to the *posterior*, byssal foramen of the bivalve!" And, if the views I advance prove correct, they were precisely right. In all my previous attempts to homologize the different classes, I had always met with an obstacle in the apparently aberrant characters of the Brachiopods: never for a moment doubting the truth of the accepted views, that indicated the regions to be called dorsal and ventral, as such, I labored in vain. When I undertook to interpret the relation of these classes on the principle of cephalization I found that these accepted views must be doubted, and it was with amazement that I beheld such unlooked for results: that the so-called anterior pole is really the posterior pole, and that the so-called dorsal region is really the ventral region.

It has not been without patient consideration that I now advance these views, knowing that by many they will be received with opposition: nevertheless, the more I try to make them comformable with already received relations, the more I am convinced that such relations are wrong; and it is only in believing that continued research will but confirm these propositions, that I now dare to offer them.

According to the views here advanced, the Brachiopods are (1) attached by a prolongation from the *dorsal* area, as in the lower Polyzoa, where they lie on the back. (2) In their natural position in life, this valve is really uppermost. (3) The process

of attachment also proceeds from the anterior pole of the body, as in all the members of the branch even to Gasteropods, with the exception of those attached by one valve (e. g. Ostreans, Clavagella), whether it be by a byssus, confined in cells of their own making, or buried in the mud, it is the anterior end which is fixed. In several lower forms, like Tridacna and Anomia, the point of attachment springs from the dorsal area, as in the two lowest classes. In regard to the posterior position of the mouth in Polyzoa and Brachiopoda, we have similar analogies among the Articulata; Cirripedia, for example, where we have animals becoming attached head downward, and all the oral parts, as in the pedunculated forms, tending toward the posterior pole of the body; or in Limulus, where we have such a decephalization, as it were, that the mouth occupies nearly a central position in the ventral region.

Again, considering the intestine as a simple tube, opening at each end, with the weight of structure evenly divided between the two openings, is it any more incredulous, that the oral opening should be posterior, than that the anal opening should be anterior, as in the Gasteropods?

In Polyzoa, the oral and anal openings occupy a similar position in all the forms. In Brachiopods, while the mouth remains in nearly a constant position, the anus terminates either in a median line, or by a lateral deflection of intestine to one side. In Tunicata, while the mouth occupies a permanent position at the front of the sac, the anus terminates at various portions of the sac, generally in a median line, though there is usually a lateral deflection of the intestine.

In Lamellibranchiata, the mouth and anus terminate in a median line, with few exceptions, (e. g. Pecten) though the intestine convolutes in various ways. In Gasteropods we have again lateral deflection of intestine, and though in many genera the anus terminates in a median line, yet in the bulk of the Gasteropods it terminates at one side or the other. In the Dibranchiate Cephalopods we have again the termination of the intestine in a median line.

The diagram here given (fig. 1) represents an ideal longitudinal section of the sac, similar to those of Series I. The arrow within the sac shows the direction of rotation of the bent intestine, carrying with it the heart, (see Plate, Series I,) which in Brachiopoda we find on the ventral region; in Tunicata on the anterior dorsal region; in Lamellibranchiata on the dorsal region; in Gasteropoda on the dorsal region and also further back; and in the Cephalopods at the posterior portion of the sac. The different positions of the sac

openings (represented in fig. 1 by arrow O) follow the same direction, that is from posterior to anterior, ventrally. Thus in Tunicata the two openings are posterior and posterior-dorsal; the posterior-dorsal, being the anal or excurrent orifice; this is always the shortest in Tunicata. In Lamellibranchiata the anal tube moves nearer the branchial tube; in the lower forms their outer covering coalescing and of equal length, while, higher up, the tubes become entirely separate, and, in some, of extreme length, the anal tube being the longest. In Pisidium and other forms the branchial tube disappears, and water is received through a ventral opening; while the anal tube yet remains, occupying a posterior position on a line with the antero-posterior axis, in the same position the branchial tube occupied in the Tunicata: and, finally, both tubes become nearly obsolete, and the mantle is cleft all round, except dorsally. Thus the progress of sac opening follows in the same line of rotation with the intestine. The progressive regions of attachment move in an opposite direction (fig. 1, arrow A). Commencing with the Polyzoa as the lowest class, we have, as in the Cheilostomata, the dorsal portion large and spreading, this being the fixed portion; the anal opening being turned toward this region, as in the Brachiopoda and Tunicata, (the movable part of the ventral surface, which is uppermost, being represented by the little lid). This mode of attachment is the lowest feature; namely, attached along the entire dorsal region.

As we ascend to the higher forms of the class, we have a freeing of the posterior portion of sac, and the viscera permanently occupies this freed portion. In the Brachiopoda we have the sac free, held only by the peduncle; the means of attachment springing anteriorly, and from the dorsal valve, as in the partially freed polyzoon. Crania and Discina are attached as in Lepralia.

In Lingula, where we have the lengthened and flattened sac, the animal stands vertical in the sand. In Terebratula and allied genera, the dorsal valve already assumes preponderance over the ventral valve, and now obtains its normal position uppermost.

All the Tunicates with few exceptions are attached, and by their anterior end.

In the compound Ascidians like Botryllus, where we have a community of individuals clustering round a common center, their dorsal as well as anterior regions are attached, or, in other words, the ventral and posterior regions are free only.

Among the Lamellibranchiata nearly all the lower forms, and many of the higher forms, are fixed or stationary; and whether moored by a byssus, buried immovably in the mud, or imprisoned in cells of their own making, it is the anterior end which is fixed. This obtains, with important exceptions.

The Monomyarians combine in their structure both high and low characters. In their open mantle, and certain other features, they rank high. In their fixed position, the attachment generally springing from the dorsal region, they rank low. For these reasons, I have placed them in the center (see Plate, Series II, M) not indicating by this their equal value with the other groups, for I doubt if their separation from the Dimyarians is valid, since the large adductor, composed of two elements, would indicate the presence of both anterior and posterior adductors, combined in consequence of the excessive shortness of their antero-posterior diameter. The Monoyarians present singular features of analogy with the Brachiopoda. Thus they are generally inequivalve. The viscera are compacted toward the dorsal region, and, when attached, they are generally by a process from the dorsal portion (e. g. Anomia), the lowest feature of attachment. In all these instances, particularly with Anomia, the analogy is very striking; it is analogy only, and nothing more, for in their whole structure, and in the relative proportion of their diameters, they present just the opposite extreme. While we have in Brachiopoda the growth laterally, that is, spreading on the sides and depressed dorsally, and the valves, dorsal and ventral, in the Monomyarians we have the other extreme; the valves are right and left, and the display is on the side, the growth extending ventrally as it were. So narrow are they that in certain forms, Placuna for example, it is almost impossible to conceive the presence of soft parts between the valves. We compare the relative diameters between the Brachiopods and Monomyarians, to show how unlike they are in this respect.

Diameter.	Brachiopods.	Monomyarians.
Antero-posterior.	Medium.	Small.
Dorso-ventral.	Small.	Very large.
Transverse.	Large.	Very small.

By reason of their excessive narrowness, the greater number of Monomyarians lie on the right or left valve, and as their peculiar form precludes the possibility of locomotion by the usual organ, the foot, they either remain fixed, or swim freely about in the water, by violently closing their valves, as in Lima and Pecten.

Among the Unionidæ, the highest family in the Lamellibranchiata, the animal assumes nearly a horizontal position in crawling, though the anterior end is always the lowest, and generally buried in the mud. Its embryos, like Monomyarians in shape, are attached to the ovisac by the dorsal margin, which is straight, as in Pecten. (Lea's paper on Embryonic forms of Unionidæ, Journ. Acad. Nat. Sci., 2d Series, vol. iv, plate 5.)

By their violent shutting of the valves, while in embryo, they may, after birth, swim, even as Pecten swims; at all events they are said to become attached by a byssal thread while young. Among the Gasteropods we have a few genera attached, or fixed, as in Magilus, Siliquaria, Vermetus, Spiroglyphus, Nerinæa, and Petaloconchus. These are now attached posterior end downward. In Calyptræa they are in a fixed position, secreting a ventral valve, upon which they rest. It would be interesting to know for a certainty which part first becomes attached in Vermetus and allied forms; their first point of attachment must take place at the mouth of the tube or aperture, which is really anterior and ventral. The Cephalopods are free.

Thus we have the various regions of attachment, changing and following in the direction indicated by the arrow A, in figure 1.

1st, Polyzoa: dorsal attachment.
2d, Brachiopoda: dorsal and anterior attachment.
3d, Tunicata: anterior.
4th, Lamellibranchiata: anterior and ventral attachment.
5th, Gasteropods: ventral and posterior attachment.

While we have thus seen that the area of attachment first springs from the *dorsal* region, and gradually changes as we ascend in structure toward the anterior end, so we find the principal organ of locomotion, i. e., the foot, is first developed from the *ventral* region, and in like manner tending toward the anterior end, as we ascend in the scale, until, in Cephalopoda, the specialized divisions of the foot surround the head, and point directly forward.

Having personally communicated the substance of this paper to Professor James D. Dana, he has, in a letter to me, indicated certain gradient relations among the Lamellibranchs, Gasteropods, and Cephalopods, as manifested in the special characteristics of the head, or anterior part of the body, so clearly illustrating the principle of cephalization that I now take the liberty of presenting them. In the Lamellibranchs the foot is a simple muscular organ developed from the ventral surface and protruding anteriorly. It is simply an organ of locomotion, in the lower forms not even performing this function. The oral opening is a simple slit, without the power of seizing or triturating its food.

In the Gasteropods the foot is more specialized, and as an organ of locomotion far superior to that of the Lamellibranchiates, having oftentimes three well characterized regions, called by Huxley, the pro-, meso-, and metapodium, these regions oftentimes supporting certain processes, e. g., cirri, opercula. The foot not only performs locomotion but in many cases has the

power of siezing and retaining its prey (e. g., Natica). The mouth has an apparatus for biting and triturating its food, being furnished with an upper jaw, or buccal plate, and a tongue, armed with siliceous particles. In the Cephalopoda the foot is so far differentiated as to be separated into prehensile arms furnished with rows of suckers, or hooks. These arms surround the head, and are thrown directly forward. They are capable not only of locomotion, but of seizing their prey, and performing also movements of aggressive action. In the higher forms of Cephalopods, the function of locomotion is delegated to other organs, while the arms subserve the uses of the head alone, and the mouth, furnished with two powerful mandibles opposed vertically, forcibly reminds us of a parrot's beak, or that of certain other vertebrates. Thus we have cephalic power manifested in the mechanical action of the foot.

1st, Lamellibranchs—Locomotion.

2d, Gasteropods—Locomotion, Prehension.

3d, Cephalopods—Locomotion, Prehension, and Aggression.

According to the principle of cephalization, cephalic power is manifested either as a mechanical, sensorial, or psychical force. Thus the Cephalopods possess in the greatest measure, all three; while Gasteropods, not indicating, to any great extent, aggressive action, may be said to manifest but little psychical power; and the Lamellibranchiates manifest essentially only mechanical action.

We have based the preceding considerations on the common structure of each class, and for comparison have given an archetype, as it were, of each class (Series I). In continuing these archetypal figures, as illustrating the relative diameters and mean forms for each class (Series II and III), and also the mean, or average position in nature of the antero-posterior axis (Series IV), we obtain singular features of polarity,[5] which I will now proceed to indicate; premising, however, that what follows is offered in reluctance, as I have not at present the opportunity to verify the statements as I would wish. In Series II the average lateral form of each class is given. In Series III a transverse section is given of the same figures in Series II. In Series II the arrow A indicates the direction of posterior pole, and D indicates the dorsal region in Series II and III. In Series IV a line for each class is given, representing the average position of their antero-posterior axis in nature (A, anterior pole, P, posterior pole). The central figures in Series II, III, and IV represent corresponding views of the Monomyarians. In the Polyzoa (Series II, P) the sac is long and cylindrical, the mouth and anus terminate at the posterior pole, and the

[5] We use this word in its most general sense.

tentacles surround the mouth only; the anus terminating outside the lophophore. Witness in the highest order of Cephalopods, the Dibranchiates, the sac as in Loligo (Series II, C), long and cylindrical, and in all cases mouth and anus opening anteriorly; the arms surrounding the mouth only. Two rough diagrams, alike in form, but reversed in one case, would represent each class as we have it here. In Brachiopoda (Series II, B) we have the sac widening laterally, and correspondingly depressed dorsally; mouth and anus opening posteriorly. In Gasteropoda (Series II, G) we have the same features, except that the parts are reversed again. In Tunicata (Series II, T) the sac is lengthened and swollen. Lamellibranchiata (Series II, L) the same. The relative diameters of the Monomyarians are unlike those of any other class, as before pointed out.

It is confidently believed that when these relations or polarities, between the ascending and descending, or, as Professor Dana terms them, the Holozoic and Phytozoic classes, have been further studied, new and interesting features will be revealed. Thus, the resemblances between the Tunicates and Lamellibranchiates are too obvious to indicate.

Among the Brachiopods and Gasteropods, beside what has been pointed out, we have unlooked for similarities, as for instance Discina and Calyptræa, or Terebratula and Hyalæa. Among the Polyzoa and Cephalopoda, though no polarities are brought to mind, except those given above, yet we cannot help remarking how strong the resemblance is between the Polyzoa and Protozoa, through Vorticella: and if Vorticella belongs to Polyzoa, as Professor Agassiz appears inclined to believe, a few steps more bring us to the Ammonitic forms of the Rhizopods. This is speculative (though suggestive), as it is now considered by many that the Protozoa forms a fifth Sub-Kingdom.

In considering transverse sections of the sacs, as shown in Series III, we obtain a like order of polarity. Thus the highest orders in Polyzoa and Cephalopoda presents a circular section. Brachiopoda and Gasteropoda are transversely oval; Tunicates and Lamellibranchiates are longitudinally oval, or in lower forms circular; while the Monomyarians have the dorso-ventral diameter in excess, and the transverse diameter reduced to the minimum.

In considering the position, or angle of the antero-posterior axis of each class in nature, we obtain similar results (Series IV).

Polyzoa and Cephalopoda, we place in a horizontal position, taking a swimming Dibranchiate for comparison: this may be premature however.

Brachiopods and Gasteropods with posterior pole slightly elevated, as in Cyrtia and allied forms of Brachiopods, and any coiled Gasteropod for example. Tunicates and Lamellibranchi-

ates with the axis vertical, the anterior pole being below, and the Monomyarian horizontal again. It must be remembered that the above considerations are taken in their most general sense, representing only the mean for each group, many of them perhaps erroneous. They are given rather for the purpose of indicating a further path of inquiry, which the writer considers fruitful and intends to follow, than as points in any way settled.

In ascertaining the mean position of the antero-posterior axis for the whole branch of Saccata, (that is, the average) we find that a line at an angle of 45° would represent its position in nature; the lower end being anterior. In the Radiates a line through the mouth to the opposite region of the body would stand vertically. In Articulates the antero-posterior axis would be horizontal. Among the Vertebrates, Fishes would be horizontal, as in Articulates; Reptiles have the head slightly elevated; Birds and Mammals still more elevated; so that a mean line, for these classes might be drawn at an angle of 45°, the cephalic region being uppermost. Man stands vertical. Thus in a diagram we would have the following:

2.

In the preceding considerations I have endeavored to show the importance of the sac, as the principle and prominent feature in their plan of structure. All animals, reduced to their primary elements, are sacs in one sense of the word, though in one case a radiate sac, in another an articulate sac, etc. Yet nowhere does this character predominate so universally, nor is it expressed so simply as in the Mollusca; the leading idea as it were. It was shown also that, essentially, the heart is on the outer bend of the intestine, or between that and the sac wall, while the principal nerve mass was on the inner bend of the intestine. We would thus state their characters.

SACCATA.

(1.) *Animals of varied forms, without a radiate structure and without articulations.*

(2.) *Stomach and viscera enclosed by a fleshy sac, which may be closed or open, at either one or both ends.*

(3.) *Principal nerve masses, consisting of ganglia, which are adjacent to, or surround the œsophagus.*

(4.) *Intestine bending inward, or having an outward flexure.*

(5.) *Heart on the outer bend of intestine.*

- SACCATA.
  - HOLOZOIC, OR TYPIC. *Mouth opens anteriorly.*
    - Sac open at anterior end. — CEPHALOPODA. / GASTEROPODA.
    - Sac open at both ends. — LAMELLIBRANCHIATA.
  - PHYTOZOIC, OR HEMITYPIC. *Mouth opens posteriorly.*
    - Sac open at posterior end. — TUNICATA.
    - Sac closed. — BRACHIOPODA. / POLYZOA.

We must now consider the relations of the Saccata to the other branches of the Animal Kingdom. In the paper of Professor Dana, above referred to, he has used the terms alphatypic, betatypic, and gammatypic, as a numbering of the grade of types, whether of branches, classes or orders; also, below gammatypic, we have degradational; the Radiates are regarded as degradational; and below this, hemiphytoid. He employs also, the terms used above, namely, Holozoic, for true animal forms, and Phytozoic, for plant-like forms.

Applying these terms to the classes or groups of Saccata, we have the following:

- HOLOZOIC.
  - Alphatypic, — CEPHALOPODA.
  - Betatypic, — GASTEROPODA.
  - Gammatypic, — LAMELLIBRANCHIATA.
- PHYTOZOIC.
  - Degradational, — TUNICATA. / BRACHIOPODA.
  - Hemiphytoid, — POLYZOA.

Prof. Dana has pointed out many interesting parallelisms between the groups of the different branches. Let us now look at the parallelisms between the groups above indicated, and the other branches. Cephalopods approach nearest the Vertebrates through their lowest class, the fishes, and already many interesting analogies have been pointed out between them.

Gasteropods may be likened to Articulates, through their lowest class, the Worms, through certain resemblances that many forms bear to the Leeches, Planarians, and Trematodes. Lamellibranchiates may be considered the essential embodiment of the branch to which they belong. Tunicates and Polyzoa may be compared to Radiates.

Or, in considering their freedom or fixedness in life, we have Cephalopods free, as in all Vertebrates; Gasteropods, a few fixed, as in Articulates; Lamellibranchiates, many fixed, as in Saccata, with relation to the other Branches. Tunicates, the greater portion fixed, though they do not compare so well with

the Radiates in this respect, but Brachiopods and Polyzoa fixed as in the lowest class of Radiates, the Polyps.

We would thus have

Alphatypic,	*Cephalopods,*	*Vertebrates,*	Fishes.
Gammatypic,	*Gasteropods,*	*Articulates,*	Worms.
Betatypic,	*Lamellibranchiates,*	*Saccates.*	
Degradational,	*Tunicates, Brachiopods,*	*Radiates.*	
Hemiphytoid,	*Polyzoa,*	*Radiates,*	Polyps.

Explanation of the Plate.

Series I. Represents a typical figure of each principal group in Mollusca—viz., P, Polyzoa; B, Brachiopoda; T, Tunicata; L, Lamellibranchiata; G, Gasteropoda; and C, Cephalopoda—(M, indicating Monomyaria of the second series). These figures are represented anterior end downward, the dorsal region being turned to the left. The tube within each cut, represents the intestine, the larger end of which is the mouth, and the smaller end the anus. The harp-shaped figure represents the heart, and the star represents the pedal ganglion.

Series II. Represents similar views, with less detail. The dorsal region in this series is uppermost, and the posterior end is turned to the left, as indicated by arrow A. The curved line indicates the intestine, the large end being the mouth.

Series III. Represents transverse sections of corresponding figures in Series II.

Series IV. Represents the mean position in nature, of the antero-posterior axes of the figures represented above: A, Anterior pole; P, Posterior pole. The vertical rows of figures are identical.

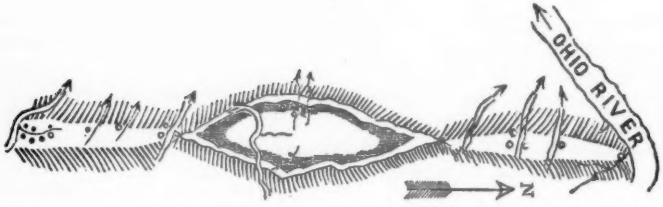
Art. IV.—*Petroleum in its Geological Relations;* by Prof. E. B. Andrews, Marietta, Ohio.

In the number of this Journal for July, 1861, I gave some facts bearing upon the geological relations of petroleum. My attention at that time was confined chiefly to those locations found in the Coal-measures of West Virginia and Southern Ohio. It is gratifying to know that the views presented in that paper have since been fully verified. As predicted, by far the larger part of the oil produced has been found along the axis of a well-marked anticlinal, extending from the borders of southern Ohio, forty miles or more, into West Virginia, through Wood, Ritchie and Wirt counties. A smaller quantity has been found in the inclined rocks of Ohio; while scarcely a barrel has been obtained in horizontal rocks, although hundreds of thousands of dollars have been expended in the search. In this portion of our great Coal-measures the question has been solely one of subterranean fissures. The chemical conditions essential to the generation of oil have existed over a wide area; but the physical condition of fissures is found to exist in comparatively limited areas. Fissures serve two purposes, one to give space for the formation and expansion of the hydro-carbon vapors, and the other to furnish receptacles for the oil when condensed. These fissures must connect with the deeply seated sources of the oil.

If they have any surface outlets, by which the more volatile portion of the oil may escape as gas, the oil within them is thickened and lowered in specific gravity. As the escape varies greatly from different fissures, we find oil of every grade of gravity. I have known oil of 52° from a well one hundred feet deep, and also oil of 28° from the bottom of one eight hundred and fifteen feet deep. The Scott well on White Oak, Wood Co., West Virginia, struck, at two hundred and seventy-four feet, a fissure containing oil of 33°, and, at three hundred and ninety-one feet, another fissure yielding an abundant supply of oil of 27½°. Hence, while, as a general rule, oil found near the surface is heavy, the fissures containing it being more likely to have surface outlets, yet sometimes the very deep fissures may have such outlets, and the contained oil be heavy.

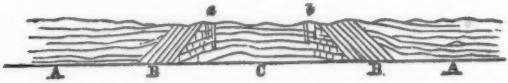
The West Virginia oil field presents many points of great scientific interest. All the productive oil wells in this part of the State group themselves along the anticlinal line marked out in the article referred to, this line being the one of the greatest fissuring of the rocks. Toward its northern and southern extremities this line presents the form of a simple anticlinal with the rocks dipping on either side of the axis at angles varying from 5° to 25°. But in the middle part there is a double fracture, the lines of dislocation inclosing a somewhat elliptical-shaped area about ten miles long by one wide. These figures are only proximate estimates. A bird's-eye view would present an appearance somewhat like that given in fig. 1. The more important oil locations are indicated by the marks ₀.

1.



A section of the dislocated strata is given in fig. 2.

2.



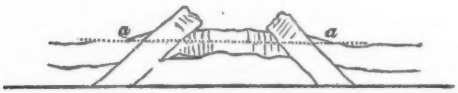
A, A represent the horizontal rocks. These belong to the highest strata of the Coal-measures. B, B represent the dislocated strata, inclining in opposite directions at angles varying

from 30° to 60°. Without having made any instrumental measurements I have estimated the thickness of these strata at about eight hundred feet. C gives the position of strata lying within what is popularly called "the break." These rocks belong to the lower Coal-measures and have been more or less flexed by lateral pressure. It is in these middle rocks that the most valuable wells of West Virginia are now being obtained. Wells bored in the rocks A, A, have been failures as also the wells bored in B, B. The rocks B, B, appear to have been lifted up bodily, and in such a way as not to have been much fissured. The advantages of the inner strata, marked C, as oil-producing rocks, are: first, they are bent and more or less fissured; second, they are many hundred feet lower in the series than the strata at A, A, and are consequently so much nearer the equivalents of the supposed sources of oil in the Devonian rocks of Western Pennsylvania and Canada; and third, this local disturbance of the rocks doubtless involves in its many fissures these underlying Devonian strata, and thus has given every opportunity for the generation of oil and its upward ascent. I think we may reasonably infer that the oil found along this line is of the same origin geologically as the oil obtained in the upper Devonian rocks of Venango Co., Pa. Thus far the oil obtained within this double fracture has been found very near the inner edges of B B, as represented by the italics, *a* and *b*. These small letters indicate, respectively, the geological positions of the "White Oak" and "Mount's Farm" wells on the western, and the Handlan wells on the eastern side. The Volcanic Oil Co. and the West Va. Oil and Oil Land Co. own large areas of land within the "breaks." The "Mount's Farm" and other companies own smaller tracts.

I cannot but regard the term "volcanic" as infelicitous when applied to this region. Nothing is more sensitive to heat than petroleum, and direct igneous action adequate to the work of uplifting and dislocating the strata to this extent would, I think, have driven off all the oil. The uplifted strata at C (fig. 2) contain seams of bituminous and cannel coal which possess the normal and average quantity of bitumen. There is, to my mind, a much better and more scientific explanation of this disturbance, one which assigns the cause to the lateral pressure produced by the subsidence of all the rocks of this region of country. This line of local uplift is found to be in the very heart or center of the synclinal part of our great coal field and at the summit of the coal formation. From forty to sixty miles both to the west and east the underlying strata, with their productive coal seams, begin to emerge. It would appear that at some time after the deposition of the last of the strata of our upper and barren Coal-measures there was a local subsidence which necessitated

such lateral pressure as would cause an uplift and dislocation. In this way alone could the sinking strata make room for themselves. For the most part along the line there was a pretty sharp anticlinal formed, but in the center of the line there were two fractures which may, I think, be satisfactorily explained. A popular illustration of the dislocation would be the case of ice fractured and heaped up by the lateral pressure of currents. It would be easy to find two cakes uplifted and forced upon a central one as represented in fig. 3; the central cake at the same

3.



time being forced upward and cracked by the force which wedges it in. If the top of the projecting mass were planed off down to the dotted line *a*, *a*, we should have in the ice phenomenon a perfect representation of the rocks in West Virginia as shown in fig. 2. We should expect that the ice would be the most fractured near the edges of the central cake and where the pressure is most direct. In like manner, experiments thus far made show that the most oil fissures have been found in C (fig. 2) near the more vertical rocks B, B. The finding of more oil near the edges of C may also be explained in part by the sloping position of the impervious strata B, B, causing the oil, which in its upward ascent might strike them, to be forced into the adjacent fissures of C. While the chances of striking fissures are doubtless greater in the rocks just within and near the lines of dislocation, yet when more extended explorations are made, I have no doubt that oil will be found in the more central portions of C. It is a fact of much interest that almost all the oil thus far obtained in these central rocks is heavy oil and found comparatively near the surface. The wells range from 20 feet to 400 feet in depth. The Harkness well yields 200 barrels a day of heavy oil from a fissure 164 feet deep. The Longmoor wells find oil in large quantities at the depth of 265 feet. The Atwater well, 198 feet deep, yields 300 barrels a day.

It should be remarked that this line of uplift has no parallelism whatever with the general range of the uplifted Alleghany mountains, but on the other hand, makes with that range an angle of about forty degrees. Hence it is difficult to suppose the two uplifting forces to have been one and the same. I have no doubt that the vertical fissure on McFarland's run, a few miles east, which is now filled with asphaltum (a fact which came to my knowledge many years ago) was produced by the same force that dislocated the rocks under consideration, and at

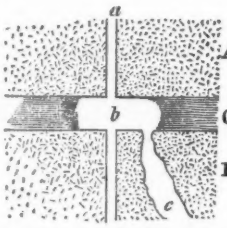
the same time. The denuding action along this line of uplift must have been very great, as, in some places, not less than a thousand feet of the Coal-measures have been eroded. I can, however, find no traces of any other agency of erosion than those now at work, viz., atmospheric and aqueous. From West Virginia this line of disturbance passes into Ohio, crossing the Ohio river near Newport, Washington Co., O., but, farther to the north, the evidences of disturbance gradually fade away. The lateral force expends itself in producing some smaller parallel undulations. The Newton well on Cow run, a branch of the Little Muskingum river, is exactly in the anticlinal axis of one of these smaller undulations. This well began to flow in June, 1861, and is, I believe, still flowing. It is 200 feet deep.

I have thus discussed the relation evidently existing between lines of geological disturbance and the production of oil in West Virginia and southern Ohio. A similar connection has been observed by Sir Wm. E. Logan in the oil fields of Canada (Geology of Canada, p. 379). The oil obtained on the upper Cumberland river in southern Kentucky has been found, so far as I can learn, in locations of similar disturbance.

But there is another and very important class of facts to be noticed in connection with the subject of the geology of oil. We find in many parts of the country a very marked tendency in the oil to accumulate in certain geological horizons. The stratigraphical position of most of the oil in southern Ohio (in the Coal-measures) is in a vertical range of about two hundred feet of rocks lying below the horizon of the Pomeroy coal seam. This is true in Meigs, Athens, Morgan, Noble and Washington counties. There are some exceptions to this rule, but they are few. On Big Sandy river in Kentucky, the conglomerate below the coal is the "oil rock." In Scioto and Pike counties in Ohio there is a well marked horizon of oil springs in the Waverly sandstone, within twenty feet of its line of junction with the underlying black shale. At Mecca, in Trumbull Co., O., there is a similar and well-defined "oil rock." But the most notable fact of this kind is observed in Venango Co., Penn., where, on Oil creek, Cherry run, and Pit-hole, the oil is chiefly obtained in the fissures of the "third sand-rock." This rock is reached at a depth of from eight hundred to a thousand feet below the base of the Coal-measures. Coal is mined in the hills adjacent to Pit-hole creek. No oil, so far as I could learn when investigating that region, has been obtained in the arenaceous shales below the third sand-rock, although a few very deep wells have been sunk. No sand-rock was found below the third. The oil is found in the third sand-rock, not because it is the third, but because it is the *lowest*, and as such has intercepted the oil in its upward ascent. I should here remark that the third sand-rock

is in some places divided into two parts by about two feet of soft shales, popularly called the "mud rock," and the lower part is sometimes called the fourth sand-rock. Oil is sometimes obtained in the mud rock. This is readily explained by the following figure (fig. 4). A and B are the upper and lower divisions of the sand-rock; C is the "mud rock" penetrated by the well *a*. The shale is softened by the water in the well, and enters the well in the form of mud. A small cavity, *b*, is thus formed, which sometimes extends to an oil fissure, *c*, and thus a good oil well is obtained..

4.



At Tideoute, on the Alleghany river, a fine oil field, the famous Economite wells struck the lowest sand-rock about one hundred and forty feet below the surface. Very deep wells have been bored in the neighborhood without finding any lower sand-rock. I had little doubt, when examining the region, that this sand-rock served the same purpose as the third sand-rock on Oil Creek; it intercepted and retained in its fissures the oil. When a fissure chanced to extend to the surface, the usual phenomena of oil and gas springs were seen. Such oil springs first called attention to that region. It would therefore appear to be a geological law in the upper Devonian rocks of western Pennsylvania that the lowest impervious sand-rock retains in its fissures the oil. In the same way the hard and compact lower strata of the Waverly sandstones of southern Ohio intercept the oil as it rises from the bituminous shales below. Some of this oil finds an outlet through fissures extending laterally to the surface of the outcropping rock. Whether by boring, at points removed from the outcrop, where there could have been no surface drainage, large quantities of oil may be found, remains to be seen. If sufficiently capacious fissures in this oil-horizon exist, I have no doubt that they will be found to contain large quantities of oil.

I would, in passing, venture to express my dissent from the opinion of some geologists, that oil which may have been formed in higher strata descends to lower. In all my investigations of this matter I have never found any evidences of such a fact, while, on the other hand, the natural tendency of oil is upward: the waters lift it up; its cognate gases often force it up; the original oil vapors rise to condense in higher and cooler cavities; and the oil which had first been condensed from vapor in lower fissures may often be re-volatilized, to ascend and find higher places of condensation near the surface. This last mentioned process may have been going on in many regions for an

indefinite period. It is possible even, that in some localities all, or nearly all, the oil has been brought up from its deep birth-places to very near the surface. In such localities very deep wells would avail nothing. It is certainly evident that on Oil Creek, Pit-hole, &c., the oil has come from below and accumulated in the fissures of the lower sand-rock. It could not have been forced down from strata above. Confining the winds in bags were an easy task compared with forcing *down* and shutting up the oil with its furious gases in the cavities of the third sand-rock. Nor could the oil have travelled in currents horizontally from the coal rocks on the southeast. This would imply that the oil penetrated diagonally the sandstones of the upper Devonian, which dip to the southeast, or that it descended vertically a thousand feet to the base of the third sand-rock and then moved under this cover to the northwest. These suppositions are entirely untenable. The oil is found in independent fissures, is of different specific gravity in different localities, and is accompanied by mineral waters varying in chemical constituents and combinations. Such facts forbid the supposition of great lateral subterranean movements. The same reasoning would apply to the theory sometimes published, that oil passes down the long slopes of gradually descending strata to the lowest part of synclinal basins, and there accumulates. Strong brine in an open permeable rock can thus descend, but not oil. If the brine carried the oil down with it, we should expect to find in the salt wells of Pomeroy, O., no little oil with the brine. The brine there is obtained in the conglomerate a thousand feet down. When oil is obtained it is from fissures comparatively near the surface.

Of the origin of the oil fissures in the sand-rocks on Oil Creek, Pit-hole, Tideoute, &c., in western Pennsylvania, I cannot speak with entire confidence. The whole region is covered with drift materials hiding the underlying rocks. There are doubtless undulations in the strata caused by the general uplifting force which gave the rocks their dip. The productive wells appear to group themselves along certain belts between which are barren intervals, and as these belts seem to be parallel with the undulations, it is probable that the oil-producing fissures are limited to the axial lines of these undulations.

The limits of a single article forbid my considering other oil fields. There are some other localities of great promise, but to discriminate beforehand these from those of no value is a most difficult task. A little oil is to be found almost everywhere in our country where the rocks are not metamorphic, and in almost every geological formation, from the Lower Silurian upward. I have seen samples of oil from nearly every western and southwestern state. I have myself found it in every stage of the

change from light fluid oil to hard asphaltum. A fine sample of bitumen, received from California twelve years ago, interested me much as containing many very old bones. This specimen prepared my mind to receive statements subsequently made, that wild animals were sometimes mired and died in the tarry oil springs in that State.

Of the origin of petroleum there are different opinions. All agree, however, that it must ultimately be traced to vegetable or animal substances, the primary combinations of hydrogen and carbon being the product of vital force. It is the opinion of Dr. J. S. Newberry and others that petroleum in its present form is the product of a slow distillation of bituminous strata. From this theory Mr. T. S. Hunt of the Canada Survey, in the "Geology of Canada," p. 526, dissents, and quotes approvingly the views of Mr. Wall, who investigated the bitumens of Trinidad, and who writes that the bitumen "has undergone a special mineralization, producing a bituminous matter instead of coal or lignite. This operation is not attributable to heat, nor of the nature of a distillation, but is due to chemical reactions at the ordinary temperature and under the normal conditions of climate." It would appear to be Mr. Hunt's opinion that the bitumens, of which petroleum is the liquid form, are the product of chemical reactions changing the original organic materials directly into oil and kindred hydrocarbons. The facts cited in proof are, that oil is found in the cavities of fossils (*Orthocerata*, &c.), and in thin strata composed of certain corals, and in similar cases, where the oil must have originated in the places where found and directly from the organic materials. I have observed many similar facts, particularly in the Devonian limestones of Ohio. These facts are conclusive so far as they go. There is no doubt that at the original bituminization of organic matter vast quantities of bitumen were formed. The greater portion of this was absorbed by the sediments which now constitute bituminous strata. For example, the black shales of the Ohio Devonian rocks are two hundred and fifty feet thick, and in them the bitumen is uniformly distributed throughout the whole mass. This distribution would imply that the bitumen was once in such a state of fluidity as to allow it to diffuse itself. In the cavities of the large *Septaria*, sometimes seen in these shales, I find among the crystals of calc spar globular masses of pure bitumen, showing that the bitumen was at least in a semi-fluid state. This bitumen originated in the shales. The diffusion of bitumen in the slates and shales often found lying directly upon seams of bituminous coal would indicate that it had been soaked up into the sediments (this process being doubtless often aided by pressure) while in a fluid or semi-fluid state. In a special study of the distribution of bitumen in the Paleozoic

rocks of Ohio which I have undertaken, and from which I hope to derive important results relative to the origin of bitumen, both animal and vegetable, the depth under water or beneath sediments at which the process of bituminization took place and the diffusion of the bitumen in certain sediments and not in others,—I think I have already found facts enough to prove that the bitumen now disseminated through our shales, &c., must once have been in a condition of fluidity somewhat akin to that of petroleum.

Mr. Hunt, p. 522, speaks of the oil-producing corals of Bertie as being "surrounded by solid crystalline encrinal limestone which is free from oil," and of the "light-colored limestones above and below" as being "not only destitute of oil but impermeable to it." In these cases the petroleum appeared to be completely confined within limestone walls only to be revealed by the well or excavation. May we not ask whether, if the surroundings of this petroleum had originally been different, that is, had there been proper sediments with suitable submergence and pressure, would not the petroleum have been absorbed and helped to constitute bituminous strata? But can we follow this reasoning beyond this point, and infer that all the free petroleum distributed throughout our wide oil fields was produced at the time of the original bituminization of organic matter, and was preserved by the nature of its surroundings from being absorbed, and that subsequently more or less of this petroleum ascended from its places of birth to accumulate in such receptacles as the fissures of the third sand-rock of Oil Creek, Pa.? If such were the origin and history of all our petroleum it would be reasonable to suppose that much of it would still be found *in situ*, i. e., where it originated; but instead of this, all the oil I have ever seen, except very insignificant quantities in isolated cavities in fossiliferous limestones, has evidently strayed far from its place of origin. It is seldom, indeed, that we find any oil in juxtaposition with bituminous strata of any kind. It is more often found in fissures in sand-rocks, rocks in which no oil could ever have been generated, for whatever organic matter they might have contained was too much exposed to atmospheric oxygen to admit of the possibility of any bituminization. It is not only impossible that the oil could have originated in these sand-rocks, or in the arenaceous shales which underlie them in western Pennsylvania, but is most probable that the oil ascended from the still lower rocks in the form of vapor which condensed in the superior cavities. In other words, the oil which, according to the theory, was formed far below in the original bituminization of organic matter, must have undergone a process of distillation.

In favor of the other theory, that petroleum, as now generally found, is the product of a distillation of bituminous shales, &c., as suggested by Dr. Newberry and others, the following arguments may be urged: 1st. Oil may be artificially produced by distilling such shales and other bituminous materials. In all essential respects, the analogy between the natural and artificial oils is complete. 2d. The phenomena of oil and gas exhibited in our oil fields greatly resemble those observed in the artificial distillation of oil from bituminous materials. These phenomena include inflammable gases, naphthas, heavy oils, asphaltums, &c. 3d. It is believed that some petroleum has been actually produced in the earth by distillation. Dr. Newberry, in an article on "Rock Oils of Ohio," thinks he finds local proof of the distillation of the petroleum in the great bituminous springs of California, from Tertiary lignites, there being evidences of recent igneous action in the region. European geologists have attributed a similar origin to the petroleums of Italy. Of course, where igneous action is intense, all the bitumen would be entirely driven off. The same would be true where the action is considerable and long continued, as in the anthracite coal region of Pennsylvania where the coal has lost its bitumen, but no oil was formed, or, if formed, it was soon dissipated in gas. 4th. There is an abundance of oil-making material in the earth. The subterranean retort is largely charged. 5th. A comparatively low temperature is believed to be adequate to set free the oil vapors. 6th. By this theory there might be produced an almost indefinite quantity of petroleum, since bituminous strata are found widely distributed. In this way the existence of petroleum in so many different geographical districts may be readily explained; whereas, by the opposing theory, we are not certain that petroleum, as such, has been produced by the direct bituminization of organic matter, except in few strata and in very insignificant quantity. Finally, the agency which would volatilize the liquid bitumen, or petroleum formed by direct bituminization, and bring it up and distribute it through the present oil horizons would certainly be adequate to distill the bituminous shales, &c., and bring up the oil to the same elevations.

It may, however, be objected, that if this theory of distillation be true, we ought somewhere to find the residuum, or debituminized shales, &c., remaining after the oil had been extracted. Such discovery could not justly be expected in surface rocks, because, according to the theory, the heat agency would at best be small and could be scarcely felt near the surface. The question, then, would be reduced to this, viz: do the borings in deep wells ever show that the deep bituminous strata have lost any of their original and normal quantity of bitumen?

I will present one or two facts which may have some bearing upon this point. I am indebted to the courtesy of Mr. R. K. Randolph, superintendent of the Carlisle Oil Co., for a record of a well 860 feet deep bored by him near Petroleum, West Va. This well is near the center of the strata marked C in fig. 2. The top of the well is in the lower portion of the Coal-measures. At 170 feet below the surface, Mr. R. struck a series of sand-rocks which continued 419 feet. I cannot suppose otherwise than that these sand-rocks are the geological equivalents of the Waverly sandstones of Ohio. Below these he passed through 265 feet of what the record terms a "gray shale with much soot." The position of these shales would make them the equivalents of the black shales of the Ohio Devonian formation, which in Ohio are 250 feet thick. They evidently contain some light carbonaceous matter in the "soot," but the record calls them "*gray* shales," not black. Mr. R. is familiar with "black shale," for he passed through two seams of it in the first 56 feet of the well. Now have these deep shales, nearly 600 feet down and situated within the double dislocation of strata already described, lost a part of their bitumen and been changed from black to gray? Unfortunately, I have not been able to obtain any sample of the borings in this shale, they, with the "soot," having been washed away. Mr. R. is boring his well still deeper. Should he soon enter the equivalents of the Cliff limestone of the Ohio Reports, I shall then feel assured that he has already passed through the exact equivalents of the Ohio Black Shales and found them "gray." Of course, such facts are not conclusive as to any positive loss of bitumen, but they are not without significance. Should I find many similar cases where strata, which are highly bituminous at their outcrop, are found to contain little bitumen at great depths, and at the same time, the rocks above these buried strata containing in their fissures much oil, I think the inference, that the oil was derived from the bituminous shales, not unwarranted.

Marietta, O., March 20, 1866.

ART. V.—*Notes on Japanese Alloys;* by RAPHAEL PUMPELLY.

THE following notes, relating to the composition of some of the many alloys in use among the Japanese, are based on information obtained from native metal-workers. In a few instances, as with the *shakdo* and *gin shi bu ichi*, the process of manufacture, generally hidden, was shown me.

I. *Shakdo*, an interesting alloy of copper and gold, the latter metal in proportions varying between 1 p. c. and 10 p. c. Ob-

jects made from this composition, after being polished, are boiled in a solution of sulphate of copper, alum and verdigris, by which they receive a beautiful bluish-black color. I can explain this color only by supposing that the superficial removal of the copper exposes a thin film of gold, and that the blue color produced is in some manner due to the action of light on this film of gold.

The intensity of the color, and to a certain extent, the color itself, are proportionate to the amount of gold, one or two per cent of this metal producing only a rich bronze color. Pure copper treated in the above solution received the appearance of an enamelled surface with a rich reddish tint, and brass a similar surface with a darker shade. *Shakdo* is used for a great variety of ornaments, as sword-guards, pipes, clasps, etc.

II. *Gin shi bu ichi* ("quarter silver") is an alloy of copper and silver, in which the amount of silver varies between 30 and 50 per cent. Ornamental objects made from this composition take, when subjected to the action of the above solution, a rich gray color much liked by the Japanese. It is used for sword ornaments, pipes, and a great variety of objects.

III. *Mokume;* several alloys and metals of different colors associated in such a manner as to produce an ornamental effect. Beautiful damask work is produced by soldering together, one over the other in alternate order, thirty or forty sheets of gold, *shakdo*, silver, rose copper, and *gin shi bu ichi*, and then cutting deep into the thick plate thus formed with conical reamers, to produce concentric circles, and making troughs of triangular section to produce parallel, straight or contorted lines. The plate is then hammered out till the holes disappear, manufactured into the desired shape, scoured with ashes, polished, and boiled in the solution already mentioned. The boiling brings out the colors of the *shakdo*, *ginshibuichi*, and rose copper.

IV. *Brasses* (*Sin chu*).—The finest quality of brass is formed of 10 parts of copper and 5 of zinc. A lower quality, of 10 parts copper and 2·7 zinc.

V. *Kara kane* (bell-metal).—First quality—copper 10, tin 4, iron $\frac{1}{2}$, zinc $1\frac{1}{2}$.

Second quality—copper 10, tin $2\frac{1}{2}$, lead $1\frac{1}{3}$, zinc $\frac{1}{2}$.

Third quality—copper 10, tin 3, lead 2, iron $\frac{1}{2}$, zinc 1.

Fourth quality—copper 10, tin 2, lead 2.

In forming the bell-metals the copper is first melted and the other metals added in the order given above. The best small bells are made from the first quality. Large bells are generally made from the third quality. The *kara kane* has a wide range of use in Japan.

Solders.—For bell-metal—brass 20, copper 10, tin 15.

For brass—first quality brass 10, copper $1\frac{1}{2}$, zinc 6.

For silver—silver 10, first quality brass 5 or 3.

For *gin shi bu ichi*—silver 10, first quality brass 5, zinc 3.
For *mokume*—silver 10, first quality brass 1½.
For *shakdo*—fine *shakdo* 3, zinc 10.
For tin—tin 10, lead 5.

Among the Japanese articles made of copper that find their way to this country, there are some with a bright red surface, which is often taken to be either a lacquer or an enamel. These objects are made of copper containing red oxyd through the entire mass, and after receiving the requisite form and a high polish, are boiled in the mixture mentioned above.

ART. VI.—*Notes on Tides at Tahiti, and Earthquake phenomena;* by Dr. C. F. WINSLOW. From a letter to one of the Editors, dated Munich, March 26, 1866.

I RECEIVED the American Journal of Science for March this morning, and have read with great interest the article on the Tides at Tahiti communicated by Prof. Bache, upon the observations of Capt. J. Rodgers.

When at Tahiti in 1844 I was immediately struck with the anomaly in the tidal phenomena. I observed the daily wave more or less regularly (but with the eye alone) on the shore and in certain inlets between Taunoa and Papiete, from the 14th of May to the 14th of June, the period of my stay there. Residing near the shore at Taunoa and walking daily to and from Papiete, and riding round the beach beyond point Venus, I constantly had opportunity for observation. The tide was low in the morning and highest from 12 to 2 o'clock, as a common observation. When on the reef off Taunoa, about the 10th of June, late in the afternoon (my notes are at home and I do not remember the exact day), the tide rose later and I was obliged to abandon my observations and collections on account of this unexpected circumstance. I remained on the reef until the sea swelled to a depth of eight or ten inches, as waves would strike the barrier and then flow strongly over it. My observations were never made with mathematical accuracy, but the latter fact accords with the imperfect records of the tide-guage established by Capt. Rodgers for the same month in 1858.

The remark of Capt. Rodgers, that "the range of the tides seems to be considerably less near the solstice, than they are near the equinox," will be found to hold as a constant truth; for upon this point I made inquiry and requested observations to be made, which were afterwards reported to me by the late Capt. John Hall, a Boston gentleman, who was for many years a merchant at Papiete. The results of the observations are that *the*

highest tides occur in December and January, and the lowest in June and July; and the general observation relative to diurnal tides at Tahiti was, that the moon exerted less control over tidal movements than in other latitudes or places in the Pacific Ocean, although similar, but less marked, anomalies existed to a noticeable extent in other more western groups.

I was at the island of Toubooai six days early in May of the same year, during which I was making more or less observations upon the reefs and shores, both on the northern and southern sides of the island. The tides appeared to flow there with their usual regularity, and rose to a greater height than at Tahiti.

I have been prompted to communicate these facts because I have long considered the tidal phenomena at Tahiti as important to physical science as they are curious and anomalous; and when carefully observed and studied, I have no doubt they will greatly enlarge our general cosmical knowledge, and establish a more correct tidal theory than exists at present, notwithstanding the high utility and value of that we now have.

While upon this subject of tidal movements in the Pacific Ocean, I will take occasion to mention that during a long period of observation upon the coast of Peru with reference to earthquake phenomena, I found, not only the highest tides to prevail at Callao and Paita in December and January, but also a series of enormous waves or sea-swells to be thrown from time to time upon the coast, varying from twenty-four to seventy hours in continuance, accompanied by unusual heights of the tide during the same period, and, on the contrary also, I remarked that the ocean exhibited an unusual tranquillity during the months of June and July. These phenomena do not appear to be connected with great atmospheric storms, nor do they hold any special relation to the force of prevailing winds near or distant, so far as I have been able to ascertain; but they increase with, and accompany, the swelling of the tides, and occur generally, not always, about the full of the moon. They sometimes break suddenly upon the coast. *They are annual and constant in their periodicity.* During my researches in the old Spanish records for earthquake phenomena, I have found them spoken of in the past century, and that they have often made ravages upon the coast to a smaller or greater degree. That which overwhelmed Callao in 1746 invaded the coast with a front swell of 40 feet, *forty-one and a half hours after* the first earthquake had suddenly devastated Lima and Callao, and *seventeen and a half hours after comparative tranquillity of the earth had prevailed.* This terrible wave extended for hundreds of miles both north and south along the coast, and seemed to be an exceptional event in *intensity* although not wholly so in periodicity, it having occurred at 4 P. M., Oct. 30th. It was without doubt connected dynamically

in some manner with the action of the internal forces which produced that series of earthquakes, one of the most violent within historic periods. A great oceanic movement was also observed upon the coast of Chili, at Talcahuana, at 6.30 o'clock, the same afternoon, without earthquakes. What is very extraordinary also, the waters of the Marañon were equally disturbed the same night on which the earthquake agitated the coast of the Pacific, as we learn by the letter of a Jesuit missionary located among the Indians east of the Andes. Without knowing what had happened at Lima, he writes as follows: "On the 28th Oct. (1746), apparently about midnight (for here we do not know exact time), a very strong earthquake occurred at this mission. I slept at the time in a ravine of the Marañon where nothing was perceived but great waves encountering from above and below, which threatened the canoes with injury; and as there was no wind, we do not understand the cause." ("Yo entonces dormi en una playa del Marañon, donde no senti otra cosa que unas grandes olas, encontradas de arriba y abajo que ponian en peligro las canoas; y por que no hubo viento no entendimos la causa." *P. Leonardo Deublér, de la Compañia de Jesus Irimaguas*, Nov. 23, 1746.) This mission was "200 leagues from Lima." The convulsion which overthrew Callao and Lima occurred at 10.30 *o'clock* P. M. *on the* 28*th of Oct.*, "five and three-quarters hours before the full moon." Nothing unusual occurred in the appearance of the ocean until 4 *o'clock* P. M. *on the* 30*th*, when a mountain of water, represented in the old accounts to fill the horizon as high as the island of St. Lorenzo when first noticed, swelled in upon the land. [In connection with this record I will take occasion to correct an *error* which prevails in the books relative to "the submergence of the old city of Callao." By careful examinations of the entire locality and of the ancient maps and records, I can state definitively that *no subsidence* took place in the site of Callao during that or any earthquake, and that the red appearances visible in some places near the shores, and which have been heretofore supposed by superficial observers to be submerged brick-work of the ancient city, are only organic and zoophytic growths of a red color which have spread themselves over larger and smaller stones. This I have determined by some personal hazard and numerous explorations.]

The periodical swellings of the Pacific Ocean, to which I have referred above, rarely begin in a notable degree before November or extend beyond February, and they are very marked from Tumbez (3° S. lat.) to the Chincha islands (14° S. lat.), between which points I have had much opportunity to observe and inquire about them. From the synchronism of periodic intensity of these oceanic phenomena with the periodic intensity of earth-

quake (or plutonic) phenomena in that region of the globe, and from the synchronism of periodic intensity of tidal movements, as they have been observed on the shores of Tahiti and of Peru, with the periodic intensity of earthquake and volcanic (plutonic) movements throughout the surface of the *entire* planet, I have been compelled to believe *solar influence* to be the predominating element in causal action, and that the lunar connection with terrestrial phenomena is reactionary rather than direct. That the periodicity and intensity of manifestation of internal dynamic energy are connected with the position of the earth in its orbit, holding inverse and constant numerical relations to the length and sweep of the radius vector, as a general law, my observations and researches have established beyond contradiction or doubt. And I have the strongest reasons to believe that systematic observations upon the oceanic movements at Tahiti and other groups in the South Pacific, and upon the coasts of Peru and Ecuador, will lead to the discovery of most important data through which our present lunar theory will be greatly developed, and probably profoundly modified.

As facts accumulate in different departments of observation, it is most interesting to discover a convergence of all terrestrial phenomena toward a central and unique causal agency. The late Prof. Kriel of Austria made many observations showing a connection of earthquakes with terrestrial magnetism. Dr. Klugé of Saxony is showing some remarkable synchronisms of volcanic eruptions with solar spots and variations of the magnetic needle. In connection with these important inquiries, Prof. Lamont, the learned director of the astronomical and magnetical observatory at Munich, lately informed me that some years since, when instituting a series of magnetic observations in a subterranean observatory, he descended one morning to examine his instruments and to his astonishment found them all in the most tumultuous agitation. He had never previously seen them in any similar state. The observatory was too profound and remote from highways to be affected by vehicles or passing loads of iron. He noted the time of this anomaly (9^h 10^m A. M. April 18th, 1842), and thought nothing more about it, until some days afterwards he noticed the occurrence of a violent earthquake in the Grecian Archipelago, and on referring to his record, found the earthquake was transpiring at the same moment with the magnetic disturbance in his observatory. Prof. Colla at Parma, Italy, made a similar observation upon his magnetic instruments the same morning. The synchronism is curious and suggestive, to say the least; and when the intensity of these various phenomena, whether internal or external to the surface of the planet, involving the dynamical tension of the air, ocean, magnetism, electricity, and plutonic force, all vary by

more or less positive ratios with *the length and sweep of the radius vector*, thus exhibiting constant relations of all tidal and periodic phenomena to the position of the planet in its orbit as it moves from aphelion to perihelion, we are compelled to look to the central body for the causal agency of every fluctuation of terrestrial force, however slight, great, or anomalous this may be.

In conclusion, I can but express my earnest hope that Prof. Bache will solicit and obtain from Congress the necessary authority and means to institute accurate and persistent observations upon tidal phenomena at Tahiti and other points in the *South Pacific Ocean*, as there are many reasons to believe that results deduced from researches made in that distant hemisphere (which is so differently formed from our own) will do more to enlarge our knowledge of mundane and planetary physics, than those instituted upon the Atlantic shores.

ART. VII.—*Further Contributions to the History of Lime and Magnesia Salts.* I.—By T. STERRY HUNT, LL.D., F.R.S.

CONTENTS OF SECTIONS.—72-80, Review of previous investigations; 81-87, Hydrated double carbonates of lime and magnesia; 88-95, Supersaturated solutions of carbonates of lime and magnesia; 96-101, Supposed decomposition of gypsum by dolomite; 102-110, Artificial formation of dolomite; 111-112, Its occurrence in nature.

IN 1859 I published in this Journal, [2], xxviii, 170, 365, the results of a series of investigations on some of the more common salts of calcium and magnesium, in the course of which I pointed out some important and hitherto unknown reactions. The prominent part which these bases play in the chemistry of the earth gives them a great interest in a geological point of view, and has led me to farther inquiries in the same direction, the results of which it is proposed to set forth in the present paper. For the better understanding of what is to follow, I shall first give a brief analysis of the principal facts detailed in the paper already referred to, of which this may be looked upon as a continuation. It will therefore be convenient for the purpose of reference to number the sections from § 71, with which that paper concludes.

§ 72. In sections 1–5 it was shown that the gradual addition of a solution of bicarbonate of soda to water holding in solution chlorids of magnesium and calcium, first precipitates the whole of the latter element as carbonate of lime, with but one or two hundredths of adhering carbonate of magnesia, and there is thus obtained at length a solution holding only chlorids of sodium and magnesium, with a portion of bicarbonate of lime, which, by evaporation at ordinary temperatures, is deposited as

a nearly pure carbonate. A similar separation of the two bases is obtained when dilute solutions of neutral carbonate are substituted for the bicarbonate of soda. These reactions are intelligible when it is considered that hydrous carbonate of magnesia at ordinary temperatures decomposes the soluble salts of lime with the separation of carbonate of lime. This is true not only for the sulphate and chlorid, but also for the bicarbonate of lime (§ 6).

§ 73. The solutions of recently precipitated carbonate of lime in the presence of an excess of carbonic acid and in water holding alkaline and earthy chlorids, were found to present some interesting peculiarities. By adding solutions of bicarbonate of soda to carbonated water holding chlorids of calcium and magnesium, supersaturated solutions, containing at the ordinary temperature and pressure from 3·4 to 4·1 grams of carbonate of lime to the liter were readily obtained. These, however, at the end of a few hours spontaneously deposited the greater part of the dissolved carbonate of lime as a crystalline precipitate, retaining of it in solution only about 0 8 gr. to the liter. From this it was evident that chlorids did not permanently augment the solubility of the carbonate, since pure water, although yielding in like manner supersaturated solutions of bicarbonate of lime, does not retain in permanent solution at the ordinary pressure more than 0·838–0·915 gr. of carbonate of lime as bicarbonate (§ 3–7). This solubility of the carbonate of lime will be farther discussed in § 88.

§ 74. According to Bischof a liter of water saturated with carbonic acid dissolves only 1·33 gr. of carbonate of magnesia; in presence of alkaline and earthy chlorids I obtained, however, permanent solutions holding not less than 21·0 gr. to the liter, thus confirming the previous results of Bineau (§ 8). In § 9 I have described the observations of this chemist and my own on the spontaneous decomposition of solutions of the sesquicarbonate of magnesia, which after a time let fall in close vessels a precipitate of hydrated monocarbonate.

§ 75. As shown above, the presence of earthy or alkaline chlorids does not augment the permanent solubility of carbonate of lime in water, and it is found that the solvent power of such a solution, aided by a current of carbonic acid is no greater for precipitated carbonate of lime than that of pure water under similar conditions, the amount dissolved being considerably less than $\frac{1}{1000}$th (§ 73).

It was, however, shown that the presence of sulphate of soda or of magnesia nearly doubles the capacity of carbonated water for dissolving carbonate of lime. Water holding either of these sulphates in solution (in the proportion of $\frac{1}{1000}$th or even less) and impregnated with carbonic acid readily takes into perma-

nent solution, at the ordinary temperature and pressure a quantity of pure carbonate of lime equal to from 1·56 to 1·82 and even 2·0 grs. to the liter.

§ 76. This increased solubility was explained by the fact of a double decomposition giving rise to bicarbonate of soda or of magnesia and sulphate of lime, of which latter salt the liquids thus obtained were nearly or quite saturated solutions. (One part of sulphate of lime, according to my determinations, requires for its solution 372 parts of water at 16° C.) By adding to these liquids an equal volume of alcohol the whole of the lime is precipitated in the form of gypsum, and the filtrate retains in solution bicarbonate of magnesia or of soda, according as one or the other sulphate was employed (§ 10–19).

§ 77. It was further found that when such a solution containing sulphate of lime and bicarbonate of magnesia was slowly evaporated at temperatures of from 30° to 70° C., the lime was deposited as crystalline gypsum, mixed with more or less carbonate, while the more soluble bicarbonate of magnesia was only separated at a later stage of the evaporation as a hydrous carbonate (§ 20–27). The presence of chlorids of sodium and magnesium does not prevent these reactions, but chlorid of calcium is of course incompatible with the existence either of bicarbonate of soda or bicarbonate of magnesia.

§ 78. It was evident that in this newly discovered reaction between solutions of bicarbonate of lime and sulphate of magnesia, together with the results of their spontaneous evaporation, we have an explanation of the origin of those numerous and extensive deposits of gypsum which are accompanied by carbonate of magnesia, generally in the form of dolomite or magnesian limestone. Before, however, inquiring into the conditions under which this double carbonate may be formed, some experiments were undertaken to determine the relative solubilities of carbonate of lime, dolomite and magnesite in dilute acetic acid at different temperatures. It was found that this reagent, first pointed out by Karsten, could be used in the proximate analysis of mixtures of magnesite, dolomite and calcite, and made to yield results of considerable accuracy. For this purpose I employed in the earlier experiments an acid containing fifteen per cent of glacial acetic acid, which was employed at a temperature of 0° C. From the experiments detailed in § 28, 29, it was evident that, although dolomite was not quite insoluble in these conditions, such a dilute acid at 0° C., might be employed to separate dolomite from carbonate of lime, and at higher temperatures for its partial separation from magnesite.

At a later period in the investigations it was found that a liquid containing only three per cent of acetic acid attacks pure carbonate of lime with lively effervescence at 16° C., and even

at 0° C., and that it is capable of being used with still greater advantage than a stronger acid for the investigation of these mixtures of carbonates. In some further experiments to be detailed below, the action of an acid thus diluted upon an excess of the mixed carbonates was made available for a process of fractional separation (§ 103).

§ 79. In § 30 the experiments of Bischof, showing the sparing solubility of dolomite in carbonic-acid water, were cited, and in farther illustration the following observation, since made, may be recorded: One gram of a very pure crystalline dolomite in extremely fine powder was suspended in little more than half a liter of water, which was then saturated with carbonic acid at the ordinary pressure, and the mixture digested for eighteen hours at about 18° C. with frequent agitation. At the end of this time the water held in solution an amount equal to 0·15 gr. to the litre of the two carbonates, in the proportion of carbonate of lime 57, carbonate of magnesia 43. In order to determine the influence of time and of a greater surface, two grams of this same dolomite were digested under similar conditions for five days, at the end of which time the amount of the double carbonate dissolved was equal to 0·39 grs. to the liter. In order to show the relative solubilities in carbonic-acid water, of dolomite in fine powder and pure precipitated carbonate of lime, a mixture of one gram of each was digested for eighteen hours with half a liter under the conditions just described, when there were found in solution carbonate of lime 0·380 and carbonate of magnesia 0·007, equal to 0·015 of dolomite; so that only about four parts of the latter were dissolved for ninety-six of carbonate of lime.

§ 80. The next point of interest in my previous paper was an inquiry into the conditions in which the double carbonate of lime and magnesia, known as dolomite, may be generated. Starting from the well known fact that gypsums are generally associated with dolomite, (although great deposits of dolomite are often without gypsum), and from the unfounded notion that such dolomites are formed by a process of alteration from previously deposited limestones, Haidinger had suggested that the origin of the carbonate of magnesia might be due to a reaction between dissolved sulphate of magnesia and carbonate of lime at elevated temperatures under pressure. This reaction was subsequently verified by von Morlot, who obtained in this way at 200° C. a mixture of sulphate of lime and carbonate of magnesia. As I have, however, shown in § 31, 32, the carbonate of magnesia thus produced does not combine with any excess of carbonate of lime present, but forms a crystalline and very insoluble magnesite, readily separated from the carbonate of lime by dilute acetic acid. In addition to the experiments

there given in proof of this, another subsequent one may be cited, where a mixture of crystallized sulphate of magnesia with two equivalents of pure precipitated carbonate of lime was heated for some hours in a closed metal tube to 200° C. The decomposition of the sulphate of magnesia was complete, and the carbonate of lime removed from the mixture held only 0·7 per cent of carbonate of magnesia, while the residue contained, besides sulphate of lime, carbonate of magnesia with only 1·3 per cent of carbonate of lime.

Marignac had endeavored to form the double carbonate by heating in a similar manner solutions of magnesian chlorid with an excess of carbonate of lime. In this case, as I have shown, the decomposition, even after several hours at temperatures of 150°–290° C. is but very partial, while the product analyzed by dilute acetic acid was chiefly carbonate of lime, mechanically mingled with magnesite and a small but variable proportion of the double carbonate (§ 34–36). In both cases the carbonate of magnesia formed at a high temperature passes more or less completely into magnesite, which, as might be expected, and as I have shown (§ 37), evinces no disposition to form with the lime a double carbonate.

In subsequent experiments, however, it was shown that when the hydrous carbonate of magnesia, mingled with carbonate of lime is exposed to heat in presence of water, combination ensues, and the double carbonate dolomite is generated between 130° and 200° C., and probably at lower temperatures. These results are given, with many details, in § 39–42, and further experiments of the same nature will be found in § 103–109.

Hydrated double carbonates of lime and magnesia.

§ 81. The results noticed in the last section gave rise to further inquiries into the affinity between the carbonates of lime and magnesia, and to the discovery of some artificial hydrated compounds of the two. The numerous hydrated double carbonates studied by Deville were all compounds of the alkalies (potash or soda) with magnesia or a magnesian oxyd. In his beautiful memoir on these salts published in 1851 (An. Ch. et Phys., [3], xxxiii, 75–106), besides a series of double salts containing alkaline bicarbonates with nine equivalents of water, Deville has described numerous neutral double carbonates having the general formula C_2MMO_6, which are either anhydrous or combined with three, four, or ten atoms of water, HO; (H=1, C=6, O=8). In these salts, which are all crystalline, the first metal is either potassium or sodium, and the second is magnesium, nickel, cobalt or copper. With zinc the formula of the double carbonate is less simple than for the preceding, being, according to Deville, $3NaCO_3,8ZnCO_3,8HO$. The mode in which these salts

are formed is instructive; a mixture of the precipitated carbonates with the alkaline bicarbonate or sesquicarbonate is transformed by a gentle heat into the crystalline double carbonates, and in the case of cobalt to a mixture of the 4-hydrated and 10-hydrated salts. A paste of magnesia alba and bicarbonate of soda with water was found to be slowly changed at a temperature of from 60°–70° C. into transparent crystals of the anhydrous double carbonate, which crystallizes in the hexagonal system and as remarked by Deville may be regarded as a soda-dolomite C_2NaMgO_6. I have already shown, § 38–40, that when this is heated to 200° C., with a solution of chlorid of calcium, the sodium is replaced by calcium, and dolomite is formed. It was with the anticipation that under conditions similar to those made use of by Deville, it might be possible to obtain double carbonates of lime and magnesia, that the following experiments, resulting in the production of hydrated carbonates, were undertaken.

§ 82. The first step was to procure a solution of the chlorids of calcium and magnesium in equivalent proportions, and for this purpose a crystalline dolomite from Galt, in western Canada, whose only impurity was a few thousandths of carbonate of iron was selected. This being dissolved in hot hydrochloric acid nearly to saturation, a little chlorine or chlorate of potash was added, and the digestion continued with an excess of the dolomite till the whole of the iron was precipitated, and a pure concentrated solution of the two chlorids in equivalent proportions was obtained.

§ 83. When the above solution is mixed with a slight excess of a solution of pure monocarbonate of soda and the resulting pasty mass heated to from 65° to 80° C., the precipitate is wholly changed in a few hours into a dense white granular matter, which, under the microscope, is seen to consist of pearly translucent globules, either single or aggregated. They are usually about $\frac{1}{200}$th of an inch in diameter, and although most frequently spherical, sometimes present the form of disks having a radiated structure and ragged edges. Lobed and compound shapes from the coalescence of these disks are also met with. This substance is so slowly attacked by cold dilute acetic acid that it was at first mistaken by me for true dolomite, and described as such in a note to the American Philosophical Society before I had discovered water in its composition. It, however, gives off an abundance of water when heated in a glass tube, even after having been dried at 35° C. In the analysis of three several preparations of this compound, in which the lime and magnesia were calculated as neutral carbonates, there was always a deficit of from seven to nine per cent, which was regarded as altogether water. In a subsequent preparation, however, it was

found that when freed by washing from all trace of chlorids it yielded a quantity of soda equal to 1·86 per cent of carbonate of soda, and moreover that there was a deficiency in the amount of carbonic acid, which was only about nine-tenths of that required to form neutral carbonates with the bases; so that the compound is a slightly basic carbonate of lime and magnesia with a little soda, and with about ten per cent of water. Further analyses are required of this substance, which appears to be nearly related to the native hydrodolomite or dolomite-sinter of Kobell.

§ 84. The magma obtained as in the last section slowly changes at ordinary temperatures into a crystalline compound much more highly hydrated than the last. A tall cylindrical jar filled with the paste of the freshly precipitated carbonates and exposed to the light at a temperature of 15° to 18° C., after twenty-four hours showed a layer of liquid at the surface from a partial subsiding of the precipitate, which, at the end of twelve days in one case, and twenty-five in another, occupied only one-seventh of the original volume. The process of change appeared to consist in the formation of nuclei, from which crystallization proceeded until every particle of the once voluminous, opaque and amorphous precipitate had become translucent, dense and crystalline. The supernatant liquid was alkaline from an excess of carbonate of soda, and held only traces of carbonate of magnesia in solution. The precipitate washed by decantation and dried on blotting paper, consisted of brilliant transparent, vitreous prisms, apparently oblique, grouped around centers, and sometimes forming little spheres five or six millimeters in diameter bristling with points. These crystals are permanent in closed vessels, but by exposure to the air slowly become opaque on the edges, without, however, losing their hardness. Heated in a glass tube they give off much water with decrepitation. The following are the results of two analyses of portions of this carbonate from the same preparation, but dried at different times by exposure to the air for several hours at about 18° C. The carbonates were supposed to be neutral though no determination of the carbonic acid was made. The carbonate of soda was separately determined on five grams, the absence of chlorids having been established, and the water estimated from the loss:

	I.	II.
Carbonate of lime, - -	37·74	36·98
" " magnesia, - -	31·38	31·06
" " soda, - -	2·18	2·18
Water, by difference, - -	28·70	29·78
	100·00	100·00

§ 85. Without farther analysis it would be hazardous to attempt to fix the composition of this double carbonate. The conditions under which it is generated are precisely those of the hydrated neutral carbonate of magnesia, and it is therefore not probable that there is any loss of carbonic acid. The carbonate of soda may exist as an integral part of the compound, or as an admixed double carbonate with lime like gaylussite. A partial loss of water in drying was evident from the aspect of the crystals, and the formula $C_2CaMgO_6, 5HO$, which requires carbonate of lime 36·5, carbonate of magnesia 30·7, water 32·8, may probably represent the true composition of this double carbonate. It is worthy of remark that the carbonate of lime and soda, gaylussite, has a similar formula, $C_2CaNaO_6, 5HO$, and that it may be artificially formed by a process which recalls that described above. According to Fritzsche when one volume of a solution of chlorid of calcium, density 1·15, is agitated with ten volumes of a solution of carbonate of soda, density 1·20, a gelatinous precipitate is formed which slowly changes into a deposit of monoclinic prisms of gaylussite, generally mixed with carbonate of lime. It was also found that a precipitate of pure carbonate of lime, after several days digestion with a concentrated solution of carbonate of soda was converted into the crystalline double salt, (Jour. fur prakt. Chimie, xciii, 339).

§ 86. In another experiment a portion of the solution of the chlorids of calcium and magnesium in equivalent portions, was by accident mixed with a quantity of carbonate of soda insufficient for its complete decomposition. The mixture was set aside and crystallized as before, but the process was slower, occupying five weeks. The liquid retained a portion of chlorid of magnesium, but only traces of carbonate of magnesia in solution. The solid product, like that described in § 84, consisted of transparent grains and groups of hard vitreous prismatic crystals. Dried in the air they became opaque but did not lose their hardness, and still gave off water with decrepitation when heated in a glass tube. Two analyses of this substance after several hours exposure to dry air, gave as follows; the bases being calculated as neutral carbonates and the water determined by the loss:

	I.	II.
Carbonate of lime, - -	51·30	50·52
" " magnesia, - -	29·97	30·09
Water, by difference, - -	18·73	19·39
	100·00	100.00

The ratios deduced from the above are nearly ten atoms of lime, seven atoms of magnesia, and twenty-one of water. From these results it is impossible to construct a simple formula, and

although Deville has represented one of the neutral carbonates obtained by him as containing three atoms of soda, eight of oxyd of zinc, and eight of water, I should prefer, pending farther investigation, to regard the above described substance as a mixture of two or more crystalline hydrocarbonates of lime and magnesia. It is worthy of note that while the simple carbonate of magnesia retains in crystallizing 6HO, the compound of one equivalent each of lime and magnesia contains only 5HO, and the last, in which the lime predominates, is much less hydrated. These double carbonates deserve a more careful study than I have been able to give them, and I publish these incomplete observations in the hope that some one may extend my inquiries, and probably correct some of my determinations.

§ 87. The hydrous carbonate of magnesia, $C_2Mg_2O_6$, 6HO, is, as observed by Fritzsche and by Soubeiran, formed under conditions analogous to the double carbonates of lime and magnesia just described. The amorphous paste obtained by mixing a solution of sulphate of magnesia with a slight excess of carbonate of soda undergoes a change precisely similar to that of the mixed carbonates, and is transformed into small prisms aggregated into spherical masses, like the double carbonates of lime and magnesia. It is tolerably permanent in the air, and yielded me 29·0 per cent of magnesia; which exactly corresponds with the above formula.

Supersaturated solutions of carbonates of lime and magnesia.

§ 88. In § 73 allusion was made to previous experiments on the solubility of carbonate of lime in presence of an excess of carbonic acid. I found that by the addition of bicarbonate of soda to a solution holding chlorids of sodium, calcium and magnesium (with or without sulphate of soda), and saturated with carbonic acid, it is possible to obtain transparent solutions holding from 3·40 to 4·16 gr. of carbonate of lime to the liter. Of this, however, the greater part was deposited in the course of twenty-four hours, and the solution was then found to hold somewhat less than 1·0 gr. of the carbonate of lime in permanent solution with an excess of carbonic acid. Comparative experiments, moreover, showed that the presence of the chlorids above mentioned does not increase the amount of bicarbonate of lime which water is capable of holding *permanently* in solution; although, as pointed out in § 56 of my recent paper on Natural Waters (this Journal, [2], xl, 196), it would seem from the comparative experiments of Boutron and Boudet that these chlorids favor the formation of unstable supersaturated solutions.

§ 89. We have now to speak of supersaturated solutions of carbonates of lime and magnesia without any excess of carbonic acid, of which a brief notice is given in the section of that paper

just cited. The power of alkaline chlorids and of chlorid of calcium to prevent the precipitation of carbonate of lime, and even to dissolve it when precipitated, has already been observed by Berthollet and by Storer (Dictionary of Solubilities, 110), but the inquiry does not appear to have been pursued farther. In like manner the power of salts of potash, soda or magnesia to prevent the precipitation of magnesia by alkaline carbonates, was noticed by H. Rose and by Longchamp (Gmelin's Handbook, iii, 225). These reactions I have made the subject of careful experiments, one object of which was to determine whether hydrated or anhydrous double carbonates of lime and magnesia might be obtained from such solutions of these carbonates containing no excess of carbonic acid.

For the following experiments there were employed solutions of pure neutral chlorid of calcium, and of pure calcined carbonate of soda, containing respectively 0·0555 gr. and 0·0530 gr. to the cubic centimeter, so that the mingling of this quantity of each would give rise to 0·050 gr. of carbonate of lime.

§ 90. I have found that the *recent* precipitate produced by a solution of carbonate of soda in chlorid of calcium is readily soluble in an excess of the latter salt or in a solution of sulphate of magnesia. The transparent, almost gelatinous, magma which results when solutions of carbonate of soda and chlorid of calcium are first mingled, is immediately dissolved by a solution of sulphate of magnesia, and by operating with solutions of known strength, as indicated above, it is easy to obtain transparent liquids holding in a liter, besides three or four hundredths of hydrated sulphate of magnesia, 0·8 gr. and even 1·2 gr. of carbonate of lime, together with 1·0 gr. of carbonate of magnesia, the only other substance present in the water being the chlorid of sodium equivalent to these carbonates. A solution of chlorid of magnesium, holding some chlorid of sodium and sulphate of magnesia, in like manner dissolved 1·0 gr. of carbonate of lime to the liter. Such solutions have an alkaline reaction.

§ 91. These solutions, which contained in all cases neutral carbonates with no excess of carbonic acid, possessed a considerable degree of stability. One prepared with 0·8 gr. of carbonate of lime and 1·0 gr. of carbonate of magnesia to the liter, was filtered after standing for eighteen hours at 16° C., and still retained in solution 0·72 gr. of carbonate of lime, which was, however, readily and completely precipitated by an equal volume of alcohol of 95 per cent. After a longer time, however, these solutions gradually deposit small transparent crystals of hydrous carbonate of lime (which also adheres as a crystalline powder to lines marked on the side of the vessel by a stirring-rod), and at the end of eight or ten days at the ordinary temperature the solution holds no more lime in solution, although still

retaining all its carbonate of magnesia. When the recent solution is boiled there is formed a copious precipitate of carbonate of magnesia, with some lime, and after evaporation to dryness in a water-bath, a portion of soluble lime-salt remains in the residue.

§ 92. The transparent crystals which are slowly deposited from these solutions contain neither magnesia nor sulphuric acid. At low temperatures they are permanent in the air, but when heated to about 30° C. change into an opaque pasty mass. Analysis gives for their composition, carbonate of lime 52·3, water 47·7. These crystals agree in their physical characters with the decahydrated carbonate of lime, $C_2Ca_2O_6$, 10HO, which requires water 47·3.

§ 93. As shown in § 75, precipitated and even crystalline carbonate of lime is permanently soluble to a large extent in solutions of sulphate of soda or of magnesia in presence of an excess of carbonic acid, in which case sulphate of lime and bicarbonate of soda or of magnesia result from double decomposition. This process is, however, entirely different from the ready dissolving of recently precipitated and as yet unaggregated carbonate of lime in solutions of sulphate or chlorid of magnesium which contain no carbonic acid, and have no power to form permanent solutions of the carbonate of lime. The difference in the condition of the lime in the two cases is readily shown by the action of alcohol, which from the first solutions at once precipitates the whole of the lime as gypsum, and from the second separates it no less completely in the form of carbonate. It suffices, however, in the second case to saturate with carbonic acid before the addition of alcohol to reproduce the conditions of the first case, and obtain, instead of carbonate, sulphate of lime.

§ 94. The solubility of the yet uncondensed carbonate of lime in neutral solutions which are without action upon it in another state of aggregation, is a good example of the modified relations presented by bodies in the so-called nascent state, which probably in this case consists in a simpler and less condensed molecule. At the same time the gradual spontaneous decomposition of the solutions thus obtained affords an instructive instance of the influence of time on chemical changes.

§ 95. I have found that monocarbonate of magnesia is still more soluble than monocarbonate of lime under the conditions described, and have in this way obtained more than 5·0 gr. of carbonate of magnesia in solution in a liter of water holding six per cent of hydrated sulphate of magnesia and a little chlorid of sodium. This solution, strongly alkaline in its reactions, gave, when gently heated, a copious precipitate, which was almost wholly dissolved after some hours repose in the cold. I have already shown (§ 23) how obstinately sulphate of magne-

sia retains a portion of carbonate of magnesia even after the solution has been long boiled, or evaporated to dryness; this is manifested by an alkaline reaction and by the power of precipitating the nitrates of silver and copper. That these reactions are due to dissolved carbonate, and not to a sulphate with excess of base, is indicated from the fact that the addition of small quantities of hydrate of soda to a solution of sulphate of magnesia gives rise to a precipitate of hydrate of magnesia which is insoluble in the sulphate, and does not communicate to it an alkaline reaction.

On the supposed decomposition of gypsum by dolomite.

§ 96. Haidinger, according to Bischof, has endeavored to explain the origin of the sulphate of magnesia observed in many gypsum quarries by supposing a decomposition of the sulphate of lime by dolomite, and Suckow has also proposed the same explanation to account for an efflorescence of Epsom salt near Jena (Chem. Geology, i, 430, iii, 159). Bischof mentions in connection with the latter instance an observation of Mitscherlich, which from the omission of a few words in the English translation, seems to imply that this chemist had observed the complete decomposition of bitter-spar by a solution of gypsum. On reference to the German edition, however, it appears that Mitscherlich had observed the decomposition of carbonate of magnesia by gypsum, and thus that his experiments do not confirm the hypothesis of Haidinger and Suckow, which we have here to examine. It is therefore by an error that in my recent essay on Natural Waters, § 19–21, I have attributed the views of these geologists to Mitscherlich, whose original memoir cited by Bischof is not accessible to me.

§ 97. In the paper just cited I have recorded the following experiments: A solution of gypsum was made to percolate slowly through a column of several inches of finely powdered dolomite previously washed with pure water. After ten successive filtrations of the liquid, occupying as many days, no perceptible amount of sulphate of magnesia was formed. Solutions of gypsum, and others of chlorid of calcium, were then digested for several months at the ordinary temperature with pulverized dolomite, and also with native crystalline carbonate of magnesia (from Styria), with similar negative results. Solutions of gypsum impregnated with carbonic acid were also allowed to remain in contact with pulverized dolomite and magnesite during the warm season for a period of six months, and even then only traces of magnesia were taken into solution.

In one experiment out of many, 10·0 gr. of pure crystalline dolomite from Galt (§ 82) and 1·0 gr. of pure crystalline gypsum were digested with 200 c. c. of water at from 15°–18° C. for six

days, when the filtrate, freed from gypsum by evaporation and the addition of alcohol, gave no trace of magnesia. The residue was then treated for the same time with water holding carbonic acid in solution, and the filtrate having been evaporated to dryness, gave to water an amount of sulphate corresponding to 0·010 of carbonate of magnesia for the 200 c. c., equal to $\frac{1}{150}$th of the weight of the dolomite. The digestion of a similar mixture of dolomite and gypsum with pure water for six days at from 50° to 60° C., with frequent agitation, gave no appreciable amount of soluble magnesian salt. When, however, dolomite was digested at this temperature with a solution of chlorid of calcium for twenty-four hours, an amount of chlorid of magnesium equal to $\frac{2}{150}$ths of the dolomite was formed.

It was evident from these and similar experiments that no reaction takes place between dolomite and solutions of gypsum even at 60° C., except in the presence of carbonic acid, whose solvent action on dolomite (§ 79) causes the formation of a small amount of sulphate of magnesia. It was then necessary to search elsewhere for an explanation of the origin of the magnesian sulphate found in the conditions observed by Haidinger and Suckow.

§ 98. The hydrous carbonates of magnesia are readily attacked by gypsum, a solution of which is soon decomposed when agitated with an excess of the sex-hydrated carbonate (§ 87) with the separation of the whole of the lime as carbonate. In like manner I have found that the white earthy hydrocarbonate of magnesia from Hoboken, N. J., gives rise to a large amount of sulphate of magnesia when digested for twelve hours in the cold with a solution of gypsum. This hydrated carbonate also completely decomposes protosulphate of iron in the cold.

§ 99. The absence of any hydrous carbonate of magnesia from the Galt dolomite was shown by its complete indifference to the action of gypsum solutions. It was, however, possible that some other dolomites might contain portions of such a carbonate intermixed. Accordingly a white earthy magnesian limestone from Chaumont,[1] belonging to the gypsiferous series of the Paris basin, was selected for experiment, pulverized, washed and dried. Of this 10·0 gr. were digested for six days with 1·0 gr. of gypsum and 250 c. c. of water at from 15°–18° C. At the end of this time sulphate of magnesia equal to 0·025 of carbonate was

[1] In a note published in 1860 in this Journal, [2], xxix, 284, I showed for the first time that the gypsum of the basin of Paris, France, is immediately overlaid by dolomite. It was there stated that two specimens of the so-called *white marls* collected by me at the gypsum quarries at Chaumont were found to contain about sixty per cent of magnesian carbonate of lime, mixed with clay. One of these specimens was traversed by veins of fibrous gypsum. As it was this dolomite which was used in the above experiment, the results of two analyses of it made at that time are here given. The rock is soft, white, earthy, somewhat conchoidal in fracture, and adheres strongly to the tongue. Hydrochloric acid attacks it but fee-

found in solution. The residue was then farther digested for the same time with 250 c. c. of a solution of gypsum saturated with carbonic acid, and gave a farther amount of sulphate equal to 0 052 gr. carbonate of magnesia. That the first action of the gypsum was upon a hydrous carbonate appears from the fact that the residue from the above processes, when farther digested for ten days in the cold with a fresh portion of pure gypsum solution and frequently agitated, gave only traces of sulphate of magnesia.

§ 100. It was, however, possible that besides hydrous carbonate of magnesia an admixture of hydrate of magnesia might also in some cases intervene to effect the decomposition of gypsum. The native crystalline hydrate, brucite, in presence of a solution of gypsum containing carbonic acid readily gives rise to sulphate of magnesia, and the rock known as predazzite is shown by the analyses of Roth and the subsequent ones of Damour to be an intimate mixture of carbonate of lime and a hydrate of magnesia similar to brucite. A portion of pulverized predazzite was found to evolve a strong odor of ammonia when digested with a cold solution of sal-ammoniac, which after seven days at 15° C. took up from the mineral 3·95 p. c. of magnesia and 0·30 p. c. of lime. 10 0 gr. of pulverized and carefully washed predazzite and 1·0 gr. of gypsum were digested for five days with 250 c. c. of water at 15°–18° C., and the liquid then

bly in the cold, and hot dilute acetic acid was employed for its analysis. The two specimens gave as follows:

	I.	II.
Carbonate of lime,	36·4	36·7 = 59·3 p. c.
" magnesia,	25·9	25·2 = 40·7 "
Insoluble,	30·1	30·2
Water, alumina and loss,	7·6	7·9
	100·0	100·0

The insoluble residue was a fine tenacious clay with a little sand. A portion separated from I. by acetic acid, and not ignited, was readily decomposed by sulphuric acid without any effervescence, and gave as follows: Silica 53·2, alumina and a little iron-oxyd 19·3, magnesia 6·4, lime a trace, water and loss 17·0, insoluble sand 4·1=100·0. This clay evidently includes, like some argillites which I have described in the Geology of Canada, page 601, a portion of a magnesian silicate, which may either exist as a double silicate with alumina analogous to chlorite, or as a simple hydrous silicate like the sepiolite or magnesian marl which is common in the Tertiary strata of many parts of Europe. (See my notice, this Journal, [2], xxxii, 286.) A specimen of this substance collected by myself near Paris in the lacustrine series known as the St Ouen limestone, which immediately underlies the gypsum, was thinly laminated and enclosed masses of menilite. It effervesced with cold acetic acid, which removed from it 9·0 per cent of carbonate of lime, and traces of magnesia. The residue was completely decomposed by heated sulphuric acid, which was blackened by a portion of organic matter present in the mineral. The analysis gave silica 58·4, magnesia 20·9, lime a trace, alumina and iron-oxyd 3·0, volatile 17·0=99·3. This silicate is readily decomposed by sulphuric acid, even after ignition. In my paper on Natural Waters, this Journal, [2], xl. 49, will be found some observations on the artificial formation of magnesian silicates, a subject which I propose soon to discuss in a separate paper.

contained but a trace of magnesia in solution. To the residue was added 250 c. c. of a solution of gypsum partially saturated with carbonic acid. After twenty-four hours digestion 200 c. c. of the liquid were found to yield on evaporation little gypsum, but an amount of sulphate of magnesia equal to 0·330 gr. of carbonate. A second portion of gypsum solution with carbonic acid being added gave, after frequent agitation for seven days, a quantity equal to not less than 3·93 gr. of sulphate of magnesia to the liter, showing that a considerable portion of gypsum besides that first in solution took part in the reaction. In this, as in all the previous experiments, a coarsely crystalline and very pure gypsum, previously pulverized and washed with distilled water, was made use of.

§ 101. From all these experiments it appears that although dolomite has at ordinary temperatures no power of decomposing solutions of gypsum, this power is preserved by the native hydrocarbonate of magnesia, which seems to be present in small quantities in some magnesian limestones. It also appears that, with the intervention of carbonic acid, hydrate of magnesia, and rocks like predazzite containing this substance, may decompose solutions of gypsum with the formation of sulphate of magnesia. The native hydromagnesite, which may be represented as a compound of monocarbonate and hydrate of magnesia, is probably resolved by a solution of gypsum into carbonate of lime and hydrate of magnesia, a mixture like predazzite, which requires, as in § 99, the intervention of carbonic acid to enable it to decompose a further portion of gypsum.

Production of dolomite.

§ 102. In § 80 I have already discussed the conditions under which the anhydrous double carbonate of lime and magnesia may be formed, and referred to the experiments in a previous paper in which I had succeeded in producing it at temperatures considerably above 100° C. It was with a hope of obtaining it at lower temperatures that many of the experiments already detailed in this paper were undertaken. Thus it was not impossible that from the supersaturated solutions holding both the monocarbonate of lime and that of magnesia, a compound of the two might be deposited. The experiments already described, however, show that the carbonate of lime separates completely after a time as a hydrate, without any trace of carbonate of magnesia. Again it was hoped that the slow union of the two carbonates at temperatures below 100° C. might give rise to the anhydrous double salt, instead of which, however, we have seen that there are formed the hydrated double carbonates already described. Attempts were next made to dehydrate these compounds and thus produce dolomite, but with partial success.

§ 103. The following experiments were made in confirmation of those described in 1859. In the examination of the products obtained, acetic acid was made use of as before, but with modifications (§ 78). A dilute acid was prepared by mixing three measures of the glacial acid with ninety-seven of water. Of this liquid, containing three-hundredths of acetic acid, there would be required in round numbers about 44 c. c. for the solution of one gram of dolomite, upon which the action is comparatively slow at the ordinary temperature, although this same liquid dissolves carbonate of lime with lively effervescence. By dividing into two or more portions the amount of this dilute acid required to dissolve a given weight of a preparation of the two carbonates, and keeping separate the matters dissolved by the successive portions, a fractional analysis of the material is effected, which gives results still more satisfactory than those obtained by the method described in the previous paper.

§ 104. In § 37 it was shown the anhydrous crystalline carbonate of magnesia evinces no disposition to combine with carbonate of lime, and the following experiments will show that the crystalline sexhydrated carbonate of magnesia (§ 87) is but little disposed to combination. A portion of this compound was intimately mingled with an equivalent of precipitated carbonate of lime and one-fifth of an equivalent of bicarbonate of soda, which would at an elevated temperature furnish carbonic acid that might aid the reaction of the earthy carbonates. This mixture formed into a paste with water was heated in a closed tube for two hours from 120° to 130° C., and then to 180° C. After six hours the matter was removed, washed with water and treated with acetic acid of three per cent, which at 0° C. produced a lively effervescence. The portion thus dissolved consisted of carbonate of lime with but 3·3 p. c. of carbonate of magnesia, while the residue was slowly but completely soluble in hydrochloric acid, and was carbonate of magnesia with only 3·2 p. c. of carbonate of lime. From this it appears that a portion of the double carbonate is formed in this experiment and remains mingled with resulting magnesite. In another experiment, in which no bicarbonate of soda was added, the portion soluble in dilute acetic acid contained 90·3 of carbonate of lime and the residue only 6·8 p. c., the remainder being carbonate of magnesia. The result of these experiments, like that of von Morlot, is thus chiefly a mixture of carbonate of lime with magnesia.

In the above as in all the experiments at temperatures over 100° C., here described, I have made use of bronze tubes holding about 14 c.c., with screw-caps made tight by an interposed disk of lead, and heated in an oil-bath.

§ 105. It was next to be seen whether the hydrous double

carbonates would yield dolomite by dehydration. For this purpose a portion of the hydrocarbonate formed at the ordinary temperature (§ 84) was slowly heated with water to 180° C. The coarsely granular residue was treated by successive portions of acetic acid of three per cent, by which it was at first readily attacked. The last or fourth part was not perceptibly acted upon by cold dilute hydrochloric acid, but required heat and long digestion with this acid to effect its solution. The composition of the successive portions was as follows:

		Calc. Carb.	Mag. Carb.
I.	21 parts,	90·36	9·64
II.	21 "	99·06	·94
III.	20 "	82·09	17·91
IV.	38 "	9·52	90·48

These results show that as in the preceding section but little dolomite is formed, though the proportion of lime which still remains in IV, indicates a certain amount of the double salt. The presence of nearly ten per cent of magnesian carbonate (in which form the dissolved base is calculated) in I, as contrasted with less than one per cent in II, seems to be due to a partial decomposition of the magnesian carbonate during its dehydration, involving a loss of carbonic acid and the formation of hydrate of magnesia. A similar result is seen in the second experiment of the last section, while in the previous experiment this was to a great extent prevented by the presence of bicarbonate of soda.

§ 106. A portion of the hydrocarbonate with excess of lime-salt, described in § 86, gave, when treated like the last, a somewhat larger admixture of dolomite, and when the hydrous double carbonate formed at 80°–90° C. was gradually heated with water to 180° C., the fractional analysis of the product showed that a large proportion of dolomite had been formed. The composition of the first and last portions was as follows, the second having been lost, and the third completely dissolved.

		Carb. Cal.	Carb. Mag.
I.	25 parts,	58·3	41·7
II.	43 "	undet.	undet.
III.	32 "	46·5	53·5

§ 107. In another trial with a granular double carbonate prepared at about 60° C., and then heated as before, the following results were obtained by fractional analysis, a residue of pure carbonate of magnesia insoluble in acetic acid remaining.

	Calc. Carb.	Mag. Carb.
I.	66·7	33·3
II.	55·4	44·6
III.	00·0	100·0

It suffices to compare the last two results with those obtained

in the previous two sections and those recorded in § 80, to see that in the present case a double anhydrous carbonate is actually generated. While in the previous preparations with sulphate of magnesia and carbonate of lime, or with the more hydrated double carbonate, the separation of the two carbonates by dilute acid is nearly complete, a large amount of carbonate of magnesia is in this case dissolved with the first portion, and the residue is, by the farther action of the dilute acetic acid, shown to be a mixture of dolomite with magnesite.

§ 108. But the most favorable conditions for the artificial production of dolomite, so far as yet observed, are attained with an intimate mixture of the two carbonates in the amorphous state, as precipitated by a slight excess of carbonate of soda from the solution of equivalent proportions of the chlorids of calcium and magnesium. (§ 82). To effect the union of the two carbonates the heat should be very gradually raised to 120°–130°, and there maintained for an hour or two. The following are results obtained from preparations thus obtained and submitted to fractional analysis by means of acetic acid of three per cent.

A precipitate of the two carbonates was made as above, pressed in linen, and the unwashed pasty mass gradually heated, thirty minutes being taken to raise the temperature from 100° to 140° C. Of the washed and dried matter the first thirty-four per cent contained 56·6, and the last ten per cent 53·0, of carbonate of lime. Another and partially washed precipitate of equivalents of the two carbonates, which had been dried at the ordinary temperature, and again moistened with water and heated to 170° C., was treated with successive portions of acetic acid with similar results to the preceding. The last residue of twenty-one per cent consisted of carbonate of lime 52·7, carbonate of magnesia 47·3.

It is unnecessary to multiply the descriptions of results of this kind obtained from five or six different preparations, and all showing that under the influence of heat the pasty mixture of the two carbonates yields an anhydrous, sparingly soluble compound having the chemical character and composition of dolomite, which requires carbonate of lime 54·35, carbonate of magnesia 45·65.

§ 109. In another experiment a mixture containing more than an equivalent of magnesian carbonate was heated as above described, and the portion dissolved by the first action of the acid contained 48·6 per cent of carbonate of magnesia, while the second portion dissolved had only 47·0 per cent, and the residue was pure magnesite. The excess of magnesia in the first fraction over the second would seem to be due, as in § 105, to a partial decomposition of the excess of hydrated magnesian carbonate in the mixture.

§ 110. Carbonic-acid water may be employed instead of acetic acid as a solvent for the analysis of artificial dolomite (§ 79). In a preparation of dolomite made in the way just described, and containing an excess of carbonate of magnesia, (52·0 per cent), the action of 500 c. c. of water saturated with carbonic acid during two and a half hours, removed from one gram 0·453 gr. containing only 48·5 per cent of magnesian carbonate. The residue, from which the more finely divided portions had thus been removed, was very slowly attacked by a solution of carbonic acid, a second portion of 500 c. c. of which, after four hours, took up 0·145, and a third portion, after eighteen hours more, 0·162 gr. of the two carbonates, in both cases consisting of carbonate of lime 53·0, carbonate of magnesia 47·0.

§ 111. In concluding this part of the subject it is to be remarked that two things in the history of dolomite may be regarded as established: first, its origin in nature by direct sedimentation, and not by the alteration of non-magnesian limestones; and second, its artificial production by the direct union of mixtures of the carbonates of lime and magnesia at temperatures above 120° C. The question next arises whether all dolomite strata have been exposed to such a temperature, or whether there are yet unknown conditions under which the double carbonate can be found at lower temperatures.

The magnesian limestone from the elevated coral island of Matea, described by Dana (this Jour., [2], xiv, 82), is, according to the analysis of Silliman, and my own subsequent examination and analysis (Ibid., [2], xix, 429), a true dolomite with a slight excess of carbonate of lime, and is regarded by Dana as of recent origin, and as derived, in some way, from the alteration of coral mud. If this origin be established beyond a doubt, it is to be remarked that the separation of carbonate of magnesia from sea-water requires peculiar conditions, which evidently are rarely fulfilled in the case of these coral deposits; and its production being conceded, the volcanic agencies so active in these regions may have very well furnished the heat requisite to form dolomite before the elevation of the island.

§ 112. Apart from the formation of stratified sedimentary dolomite, we have also to keep in mind the frequent occurrence of this double carbonate as a mineral of secondary deposition, lining drusy cavities, filling veins, and even the moulds of fossil shells (§ 52, 53). The conditions of its deposition from natural waters are probably not unlike those of the quartz, fluor, and heavy-spar, with which, in its form of bitter-spar, it is often associated, and as subjects for farther investigation, may yet throw more light on the agencies which have effected the union and crystallization of the two carbonates in sedimentary deposits.

Montreal, Jan. 1866.

ART. VIII.—*Remarks on the new division of the Eocene, or Shell Bluff Group, proposed by Mr. Conrad;* by EUG. W. HILGARD, Ph.D., State Geologist of Mississippi.

IN a brief paper published in the January number of this Journal, Mr. Conrad proposes to distinguish, as a separate group of the American Eocene, a series of deposits but feebly represented at Vicksburg by a five-foot stratum of dark lignitic clay and sand, differing in its paleontological characters from both the Vicksburg and Jackson group. Mr. Conrad considers it to be especially characterized by the occurrence of *Ostrea Georgiana*, and defines it as *underlying* the "Orbitolite limestone of the Jackson Group." He also mentions, in the section of the Vicksburg Bluff, the Orbitolite limestone, as a representative of the Jackson group.

The latter supposition is manifestly an oversight on the part of my honored friend. That the group of fossils described by him, and figured in Prof. Wailes's Report, as Jackson fossils, do not *occur* at Vicksburg, I need not recall to his mind; but he has overlooked the fact that the *Orbitoides Mantelli*, throughout the state of Mississippi, at least, is entirely absent from the Jackson Group, the Orbitoides limestone being invariably accompanied by *Pecten Poulsoni*, *Arca Mississippiensis*, *Ostrea Vicksburgensis*, and other leading Vicksburg fossils.

Of *Ostrea Georgiana* I have unfortunately never seen an authentic specimen or description; but from the facts stated by Mr. Conrad, and his comparing it to *P. longirostris* Lamk., I unhesitatingly identify it with specimens from Vicksburg, labeled "*P. gigantea*" by Prof. Wailes. Upon the authority of the latter observer, Mr. Conrad mentions the occurrence of *O. Georgiana* at Jackson. There is, indeed, some resemblance between the lower valve of the oyster so abundant at Jackson (which, together with the bones of the Zeuglodon, characterizes the "shell prairies" of central Mississippi, as stated p. 128 of my Report, and some specimens of *O. Georgiana;* but in their general character, when seen in *series*, they differ widely, the Jackson oyster having distinctly the habitus of a *Gryphæa*, and oftentimes resembling closely *G. convexa* of the Rotten limestone. It is one of the leading fossils of what I have most unequivocally recognized as the upper member of the Jackson group; it occurs at Jackson itself, on the hill-tops, associated with *Zeuglodon* bones, *Umbrella planulata*, *Cyprœa fenestralis*, *Morio Petersoni*, *Conus tortilis*, and others, in stratum No. 7 of section 27, page 131 of my Report. The Jackson fossils described by Mr. Conrad are derived from Nos. 4 and 5 of that section.

In the numerous localities where I have studied the beds of the Jackson group, I have never found a single Orbitoides associated with them. The constant concomitant of the latter fossil, the *Pecten Poulsoni*, also is absent from the Jackson strata, being replaced by *P. nuperus*, Con.

But if the Orbitoides limestone is no member of the Jackson, but on the contrary, a characteristic one of the Vicksburg group, then it is clear that the strata of the "Shell Bluff group" at Vicksburg lie *above*, and not below the Jackson strata. For it cannot be supposed that the latter, which occupy so extensive an area above Vicksburg (see the map accompanying my Report,) should suddenly come to an end, and leave no trace of a representative between the Shell Bluff and the Vicksburg groups did it belong there.

There is only one other locality in the state, as far as known, where *O. Georgiana* (i. e. the large oyster occurring at Vicksburg) is found, viz: in Jasper county, Miss., where it was collected by Prof. W. D. Moore, late of the University of Miss. It there occurs again in the same outcrop with *Pecten Poulsoni, Orbitoides*, and a *Schizaster*, which is also a leading Vicksburg fossil; this locality being, likewise, considerably south of the shell prairies of the Jackson group.

As there is nothing to justify the assumption of a sudden termination of the strata of the latter group, which, on the contrary, may be seen disappearing under those forming the transition to the Vicksburg strata, with remarkable regularity, along the course of both Pearl and Chickasawhay rivers, (see p. 135 of my Report), the conclusion is inevitable that *the Jackson group is older than the Shell Bluff group* as defined by Conrad.

That there may be a considerable difference in the geological horizons of the Jackson and Vicksburg groups proper, sufficient to admit of the existence of a fauna deserving to be formed into a distinct group, is proved, not only by the paucity of coincident species, (see list, ibid, p. 132), but no less by the considerable thickness of the intervening strata in eastern Mississippi, on the Chickasawhay river, which near Red Bluff Station (ibid, p. 135,) amounts to over one hundred feet.

Here, as at Vicksburg, we have, underlying the Orbitoides, marls and limestones, a stratum of inconsiderable thickness, but literally teeming with shells, which are a strange mixture of the faunas of Jackson and Vicksburg, with numerous peculiar species (see list, ibid, p. 136). Here also, we have a *Madrepora*, distinct from, but closely allied to, the species found in the "Georgiana bed" at Vicksburg; where in its turn we find an extraordinary number of valves of *Meretrix sobrina*, a *rara avis* in the Vicksburg strata proper, but abundant in the Jackson group. *Busycon undulatum*, also, is a Jackson form, if not

species. The number of species thus far found in this bed is, however, too small to allow us to expect numerous coincidences either way. *Ostrea Georgiana* does not occur at Red Bluff, the greater part of whose strata, immediately superimposed upon the Zeuglodon beds, are extremely poor in fossils.

Of course, these data are insufficient as yet to parallelize Mr. Conrad's Shell Bluff and my Red Bluff group. But their relative positions seem to be at least analogous, and I sincerely hope Mr. Conrad will, before many months, give both the collections of the Mississippi Survey, and the localities themselves, the benefit of his personal inspection.

I should add, in conclusion, that the Jackson and Vicksburg groups are by no means always thus separated by intervening beds. In one locality, at least, at the extreme southern edge of the marine Tertiary, I have seen the white Orbitoides marl directly superimposed upon a bed of blue marl containing *Monoceros vetustus* and *Morio Petersoni*, with a *Rostellaria* thus far called *R. velata*, but which is certainly a species distinct from the Claiborne fossil of that name.

ART. IX.—*Preliminary Notice of certain beds of Fish-remains, in the Hamilton group of Western New York;* by FRANK H. BRADLEY.

ACCOMPANYING the Moscow black shale of the upper part of the Hamliton group, at Geneseo and Moscow, Livingston county, and East Bethany, Orleans county, N. Y., are certain thin lenticular masses of impure pyrites, which contain large quantities of the teeth, fin-spines and bony-scales, of fishes, and numerous Mollusca.

The layers composing these beds are very variable in thickness and in composition, some being quite solid and composed almost entirely of pyrites; others, thin and fragile, and interlaminated with layers of black shale. The latter portions commonly contain the bones, while the more solid portions yield shells most numerously.

It would seem that the sulphur of the pyrites must have come from the decomposed fish, and that the beds correspond to the deposits of fish-remains reported by dredgers in certain seas, while the surrounding bottom yields not a fragment.

Information concerning the situation of these localities was given by Mr. H. A. Green in the January number of this Journal.

So far as I have been able to ascertain, they had not been explored by any one previous to my visit in July, 1864, at which

time, as well as in the succeeding year, I collected largely therefrom for the cabinet of Yale College. I have also employed Mr. Green to increase my collections. The specimens thus obtained are sufficient to indicate the existence of at least two or three species of fish, and to show the principal characters of one of them. It is hoped that further explorations, now in progress, will be still more successful.

The most common species has a two- or three-forked tooth, somewhat resembling that of *Diplodus*. The scales are all pustulose: some are rectangular, measuring one to two inches on a side; others are curvilinear, one of which measures six inches across (probably a distinct species). One large, probably interior, bone measures three by four inches, with a thickness, at one end, of over an inch. One jaw is between three and four inches long.

These remains all retain their bony structure, though some of the larger and more porous fragments are thoroughly permeated with the pyrites.

Accompanying these remains are very numerous shells of Cephalopods, Gasteropods, Brachiopods, and Lamellibranchiates, which are mostly replaced with nearly pure pyrites, and separate readily from the rock, with very brilliant surfaces.

A few of the Orthocerata retain their calcareous structure, and also have their cavities mostly filled with calcite. The same mineral is sometimes found in the interior of the Goniatites which are common in the beds.

Of *Goniatites*, there are at least three species, besides a very minute form which I am inclined to call the young of *G. uniangularis*, but which may prove distinct. Of Gasteropods, we have twelve or fifteen species; probably as many Lamellibranchs; and five or six Brachiopods. Excepting the Goniatites, which are sometimes two inches across, the shells are all minute.

A few specimens of three or four small species of *Pentremites* have been found, and the stems of larger crinoids are quite common in some layers. Corals are very rare.

Many of the species will very probably prove identical with those which crowd the Hamilton blue shales, but I have reason to think that most of them are new. No careful examination and comparison have as yet been made; but I hope that it may, ere long, be completed, and the results published.

In this connection, the following fact may be interesting:

From the *Black slate* of the Hamilton group at the West, which has proved almost entirely barren wherever worked, a German clergyman residing at Delaware, Ohio, has recently obtained, at that locality, nearly the whole of a thick, heavy

pustulose scale, measuring about ten inches by fourteen; the pustules are about one-fourth of an inch in diameter. Considerable digging was done, but no further discoveries made.

Being absent from home, I have not the opportunity of referring to my specimens, and I cannot therefore make the present notice more complete.

Panama, U. S. C., May 11, 1866.

Art. X.—*On the Ammonium Amalgam;* by F. S. Pfeil[1] and Henry Leffman.

For some years the attention of chemists has been directed to the investigation of the substitution ammoniums. Notwithstanding their close analogy to ammonium itself, in many respects, we have not been able to find record of any systematic attempt to form amalgams analogous to the well known ammonium amalgam. The consideration of this fact induced us to commence a series of experiments to determine the deportment of these bodies with sodium amalgam.

A saturated solution of chlorid of trimethyl-ammonium was treated with sodium amalgam, and a series of phenomena followed exactly identical with those which occur in the preparation of the ammonium amalgam. The swelling rapidly subsided, hydrogen gas being given off, and the liquid was found to contain trimethylamine.

Saturated solutions of the chlorohydrates of aniline, conine, morphine and quinine, and of the acetate of rosaniline, when treated with sodium amalgam, give rise to copious evolution of hydrogen gas, without turgescence.

These experiments (in addition to those recorded by Dr. C. Wetherill) seem to indicate that the physical phenomena of the ammonium amalgam depend entirely upon the retention of gas bubbles, and also that those ammonias which, in the free state are, at ordinary temperatures, either liquid or solid, produce no amalgam.

It may be mentioned that a solution of chlorid of ammonium in pure glycerine gives rise to an amalgam, but the turgescence is much interfered with by the viscosity of the solvent; and also that sodium amalgam, when placed upon a crystal of chlorid of ammonium, produced no reaction until moistened with a drop of water.

[1] The address of F. S. Pfeil is 1437 North 11th street, Philadelphia.

ART. XI.—*On Danalite, a new Mineral Species from the Granite of Rockport, Mass.;* by JOSIAH P. COOKE, Jr.

DISSEMINATED through the Rockport granite, which is quarried at the extremity of Cape Ann, Massachusetts, and much used for building in Boston and the vicinity, are occasional grains of a flesh-red mineral somewhat resembling Rhodonite.

The mineral has been at times found in masses of considerable size, and for a specimen of this sort I am indebted to the kindness of Mr. W. J. Knowlton, of the Lawrence Scientific School.

The characters of the mineral are as follows: Color, flesh-red to gray. Streak similar in color to the mineral but lighter. Lustre, vitreo-resinous. Translucent. Fracture subconchoidal uneven. Brittle. Hardness 5·5 to 6. Specific gravity—two determinations—3·427. The exterior portion of the mass showed no indication of crystalline form and there was no distinct cleavage; but on breaking it open a well developed octahedron of the regular system was found in the interior. The angle between the octahedral faces measured with an application goniometer 109° 30′. The edges of the octahedron were replaced by planes of a rhombic dodecahedron, strongly striated parallel to the longer diagonal of the face. The mineral, therefore, crystallizes in the *holohedral* forms of the monometric system.

Before the blowpipe the mineral readily fuses on the edges to a black enamel. Hence its fusibility is about 4 of von Kobell's scale. On charcoal with carbonate of soda it gives a slight coating of oxyd of zinc. In a closed tube it loses color, but gives off no water or any sublimate. It is perfectly decomposed after some time by hydrochloric acid, the silica partly gelatinizing. It is also decomposed by nitric acid; but then the silica separates as a powder. It is partially decomposed by dilute sulphuric acid, and even by acetic acid, sulphid of hydrogen gas being evolved.

In order to thoroughly decompose the mineral the material was finely pulverized and sealed up with some concentrated acid in a glass flask, which was then exposed for several hours to the heat of a water-bath. When hydrochloric acid was used a slightly greenish solution was obtained, frequently depositing crystals of protochlorid of iron on cooling, but showing no traces of sesquichlorid, and on opening the flask a strong odor of sulphid of hydrogen was observed. When nitric acid was used the flask became filled with nitrous vapors, and both the iron and the sulphur were completely oxydized. A qualitative analysis proved the mineral to be a compound of silica, glucina, protoxyd of iron, oxyd of manganese, and oxyd of zinc, mixed with the sulphids of the last three metals. The presence of

alumina could not with certainty be detected by any known tests. The precipitate of glucina perfectly redissolved in an excess of carbonate of ammonia, and no crystals of alum could be obtained from a solution of the sulphate when treated in the usual way with an excess of sulphate of potash, although they were sought for with a microscope.

As the sulphid of hydrogen which is evolved from the metallic sulphids, when the mineral is decomposed by hydrochloric acid in a closed flask, would necessarily reduce all the iron present to the condition of proto-chlorid, the following experiment was made to determine the original condition of the iron in the mineral. It is evident that any such reduction must be attended with the separation of free sulphur, and hence sulphur was sought for in the products remaining in the flask after the decomposition was finished. The sulphid of hydrogen and the greater part of the free hydrochloric acid having been first expelled, the residue was boiled with an excess of concentrated nitric acid, and as no trace of sulphuric acid was found it was concluded that the iron in the mineral, not united with sulphur, was all in the condition of protoxyd. The same experiment also proved that none of the varieties of iron pyrites could be present in the mineral in distinct grains, as was at first suspected; and this conclusion was confirmed by the fact that a powerful magnet failed to attract any portion of the mineral, even when reduced to the finest powder.

In the quantitative analysis no unusual methods were employed. The mineral was decomposed in a sealed flask as described above, sometimes by hydrochloric but usually by concentrated nitric acid. The silica was separated in the ordinary way and its purity tested by hydrofluoric acid, the small amount of residue, which was in some cases obtained, being carefully determined and estimated in calculating the final result. The iron was then precipitated as basic acetate, and this precipitate carried down with it a portion of the glucina. From the filtrate the manganese was separated by bromine, and the zinc was precipitated by sulphid of hydrogen. The filtrate from the sulphid of zinc was always found to contain the larger part of the glucina,[1] which was precipitated by ammonia. The glucina thus precipitated was weighed down by itself and the amount added to that subsequently separated from the iron. This last separation was effected by a simple modification of Deville's method which will be described at the end of this article. Lastly, the sulphur, which now remained in solution as sulphuric

[1] We have never succeeded in precipitating the whole of the glucina as basic acetate, although carefully attending to all the precautions which have been indicated by other analysts. But alumina is perfectly precipitated when the necessary precautions are observed.

acid, was determined as sulphate of baryta in the usual way. The results of my analyses were as follows:

	1.	2.	3.	4.	Mean.
Silica, - -	31·74	31·54	31·96	31·69	31·73
Protoxyd of iron, -	....	....	25·71	29·09	27·40
Oxyd of zinc, -	17·90	16·90	19·11	16·14	17·51
Oxyd of manganese, -	5·83	6·64	6·17	6·47	6·28
Glucina, - -	....	....	13·86	13·79	13·83
Sulphur, - - -	....	....	5·93	5·02	5·48
			102·74	102·20	102·23
Oxygen equivalent to per cent of sulphur,			2·96	2·51	2·74
			99·78	99·69	99·49

For analysis 4 the material used was a portion of the crystal described above. When in mass it had a bright flesh-red color, and even in the powder the color was still quite decided. The material used in analysis 3 was taken from a wholly different portion of the specimen. The red tint was less marked and the color of the powder was decidedly gray. These two portions were selected as presenting the most decided contrasts of color observed. Analyses 1 and 2 were made before the composition of the mineral was correctly known, and the best method of analysis discovered. Hence, only a portion of the bases were accurately determined, and only those results are given which are known to be trustworthy. The material for all the analyses was selected with great care; but that used in 4 being a portion of a crystal from the center of a large mass was unquestionably the most pure.

The most natural theory of the constitution of the mineral, to which the above results and the crystalline form both point, is that the mineral is an isomorphous mixture of a monometric silicate with the simple sulphids of iron, zinc, and perhaps of manganese, all of which affect the same crystalline form. These different sulphids must be present in somewhat varying proportions; for while in 4 the sulphid of iron is evidently in excess, the sulphid of zinc equally predominates in 3, and such a difference is plainly indicated by the difference of color already mentioned. This view is also sustained by the action of different acids on the pulverized mineral. Dilute sulphuric acid attacks the powder even when cold, sulphid of hydrogen being evolved, while iron and zinc in large quantities, with some glucina, enter into solution. Even dilute acetic acid causes an evolution of sulphid of hydrogen dissolving an abundance of iron, but also some glucina. Since now sulphid of zinc is insoluble in acetic acid this last reaction points clearly to the presence of sulphid of iron in the mineral; but at the same time both experiments indicate that the metallic sulphids are so intimately associated with the silicate that the decomposition of the first involves to

a limited extent at least the breaking up of the last. This is what we should naturally expect in an isomorphous mixture, the sulphids not being present in separable grains; but diffused through the mineral in a state of imperfect chemical combination, and thus rendering even a firm silicate exceedingly susceptible of decomposition.

On examining the results of analysis given above it will further appear, in support of the same theory of the constitution of the mineral, that while the proportions of silica, glucina, and even of oxyd of manganese, are very constant, the proportions of the oxyds of zinc and iron vary very considerably; these metals, although in the analyses separated and determined as oxyds, being, in fact, combined to a greater or less extent with sulphur in the different portions of the mass examined. If now we calculate on this view the oxygen ratio of the silicate, deducting of course from the sum of the oxygen of the bases, an amount of oxygen equivalent in each case to the per cent of sulphur found, it appears, taking the mean result, that the sum of the oxygen of the bases is to the sum of the oxygen of the silica as 16·93 : 16·81, or very nearly as 1 : 1. Moreover, if we regard glucina as a sesquioxyd base we shall have for the oxygen ratio between protoxyds, sesquioxyds and silica, the proportion 8·22 : 8·71 : 16·81 or very nearly as 1 : 1 : 2. Again, the amount of sulphur in the metallic sulphids is very nearly one-sixth of the amount of oxygen in the silicate; so that for every twelve equivalents of oxygen in the silicate we have one equivalent of sulphur in the sulphids. Hence we deduce as the general formula of the mineral

$$(\tfrac{1}{3}\dot{R}_3 . \tfrac{1}{3}\ddot{B}e)\ddot{S}i + \tfrac{1}{4}RS \text{ in which } R = Fe . Zn . Mn.$$

The oxygen ratio of the new mineral is the type ratio of the garnet family, and to this family it undoubtedly belongs. Its mineralogical characters would place it intermediate between Willemite and Iron Garnet where by its composition it naturally falls. This relationship appears in the following table; but it is seen much more clearly on comparing the actual specimens:

	Willemite.	Danalite.	Iron Garnet.
Action of hydrochloric acid,	Gelatinizes easily.	Gelatinizes, but less easily and perfectly.	Decomposed, but does not gelatinize.
Before blowpipe,	Fuses on edges to white enamel.	Fuses more readily to black enamel.	Fuses easily to a bead.
Sp. gr.,	3·89 to 4.	3·427.	3·7 to 4·2.
Hardness,	5·5	5·5 to 6.	6·5 to 7·5.
Luster,	Vitreo-resinous, weak.	ditto, stronger.	ditto, brilliant.

It is true that Willemite and Garnet belong to different crystalline systems, but the ordinary form of Willemite really ap-

proaches very nearly a rhombic dodecahedron, the difference of angle only amounting to 5°, and there is no good reason for attaching a greater significance to this difference of angle between the corresponding forms of allied systems, than is attached to an equal difference between similar forms of the same system. In its peculiar constitution the new mineral is allied to Helvin, although the two species have no outward resemblance. The holohedral character of its crystallization, the very large amount of iron and zinc entering into its composition, its color, luster, hardness, and other physical as well as chemical properties, all distinguish it from Helvin and prove the mineral to be a new species. As such I take great pleasure in giving to it the name of *Danalite*, after Prof. James D. Dana, of New Haven, a name so honorably associated with American mineralogy.

Small fragments of Danalite are not unfrequently met with in the quarries at Rockport, and small grains of it, as I have already said, are quite generally disseminated through the granite ledges which form the extremity of Cape Ann. But large masses of the mineral have not been obtained for some time, the portion of the rock in which they were found having been long since quarried. The mineral was first supposed by the local collectors to be Rhodonite, and under this name good specimens of Danalite may probably be found in some of the collections of the country. Specimens of the mineral have also been found associated with green feldspar at the railroad cut near Gloucester, Mass. The mineral at this locality is more garnet-like in structure, and contains a considerable amount of alumina associated with the glucina. An analysis of a specimen from this locality gave the following results:

Silica,	29·88
Protoxyd of iron,	28·13
Oxyd of zinc,	18·15
Oxyd of manganese,	5·71
Glucina and alumina,	14·72
Lime,	0·83
Magnesia,	traces
Sulphur,	4·82
	102·24
Oxygen equiv. to sulphur,	2·41
	99·83

At Gloucester the Danalite is associated with fluor spar, which I have never recognized on the specimens from Rockport, although the granite, in which the mineral is imbedded, has at both localities a similar character. Danalite is also associated at both localities with two very remarkable varieties of lepidolite mica. These have also been analyzed and an account of the investigation will be given in a future paper.

Separation of Sesquioxyd of Iron from Alumina, Glucina, and most of the rare earths.—The method of Mr. H. Sainte-Claire Deville,[1] referred to in the above paper, is one of the most accurate processes of analytical chemistry, and would probably have been more generally used had it not been supposed that it required a furnace heat and involved the usual accompaniments of furnace work. The simple modification we have introduced is to substitute a tube of platinum for the tube of porcelain, and a Bunsen's blast lamp for the furnace. We use in the process the condenser of a small platinum still; but a smaller tube about 6″ long and $\frac{4}{10}$″ in diameter would be better adapted to the purpose, and would serve many other useful ends in the laboratory. In addition to the tube, a small platinum nacelle would be required, as large as the tube will admit and about 1½″ in length. With such an apparatus the method of conducting the process is as follows: The tube having been mounted horizontally on any convenient stand, one end of it, which is closed by a doubly pierced india rubber cork, is connected on one side with a small hydrogen generator and on the other with a small flask for generating hydrochloric acid gas. To the other end of the tube is fastened by an india rubber connector a small glass adapter, so curved that the end may dip under water. The mixed bases, whose total weight is known, having been placed in the nacelle in a finely pulverized condition, and the nacelle having been introduced into the tube, the heat of a single Bunsen burner is applied, while a gentle current of hydrogen is caused to flow through the apparatus. In the course of half an hour all the oxyd of iron is reduced to the metallic state. The current of hydrogen is then replaced by a much more rapid current of hydrochloric acid gas and the heat of a blast lamp applied. The reduced iron is now rapidly converted into chlorid, which, being volatilized by the heat and carried forward by the current, dissolves in the water. After a few minutes the action ceases, the heat is then withdrawn, and the current of hydrochloric acid gas being again replaced by a current of hydrogen, the apparatus is allowed to cool. The alumina, or whatever earth may be present, is left behind in the nacelle in a perfectly pure condition and can be at once weighed, while the weight of sesquioxyd of iron is known from the loss. If the product is not perfectly white the nacelle should be returned to the tube and the process repeated. The result can be controlled by also weighing the nacelle after the reduction of the iron, but it is not safe to estimate the amount of iron solely from the loss of weight at this time, since a very small error in this determination would cause an important error in the calculated amount

[1] Annales de Chimie et de Physique, Tome xxxviii.

of sesquioxyd. We give these details not as new, but because we feel assured that with the simple modification here described the process will be found far more expeditious, convenient and satisfactory, than any other process now in use. A small porcelain tube might be used instead of the tube platinum, but this cannot be recommended, as the porcelain is liable to break unless protected, and when properly protected sufficient heat can hardly be obtained without a furnace. The hydrogen gas is best obtained from a small automatic generator, and the hydrochloric acid gas may be generated in a small flask from coarse salt and sulphuric acid, which has been previously diluted with about one-third of its volume of water, and allowed to cool. This mixture when gently heated gives a constant flow of gas, which almost immediately stops when the lamp is withdrawn. Both gases should pass through a wash bottle containing strong sulphuric acid before entering the tube.

ART. XII.—*Memorandum of a variable or temporary Star of the Second Magnitude, seen in the Northern Crown, May*, 1866; by E. J. FARQUHAR, Assistant Librarian U. S. Patent Office.

WALKING out between eight and nine o'clock in the evening of Saturday, May 12, near Sandy Spring, Montgomery county, Maryland, and looking over the constellations in the east, I was surprised at the appearance—or apparition I may call it—of a star in the Northern Crown which I could not believe I had ever seen there before. Immediately on reaching home I looked up an atlas of the heavens, and found no such star marked upon it. I then walked over to the house of my uncle, Mr. Benjamin Hallowell, who having looked at another map of his own, and found no record of such a star, came out with me to see it. As soon as I had pointed it out to him, he remarked that he had seen it for several nights, amounting to three weeks, or as he afterwards said, a month, probably ever since the constellation had come within view of a spot where he was accustomed to take an evening walk. He is therefore, so far as I know, the first person who ever saw it. He had remarked it as an unfamiliar star, and supposed it was a planet, without considering whether any planet ever frequented there. He did not think it had changed position at all during the month, but he was inclined to believe it had varied in magnitude from time to time; though on neither of these matters will he speak positively, because he had not given the star any special attention. It appeared to be two-thirds or three-quarters of a degree south of Epsilon Coronæ. It was of a pure, soft white, and twinkled a little. Seen through a telescope that magnifies about forty times,

it showed nothing of the nature of a comet. I thought it grew brighter during that evening, but will not be certain. I believe those who carefully observed its magnitude pronounced it a little brighter than Alphacca, Alpha Coronæ. One observer seemed inclined to question this, but did not profess to be sure of his judgment in that respect. There can be no doubt that during at least part of that night, the stranger star was fully as bright as Alphacca; I think brighter. Sunday morning it did not seem to have changed in luster, but Sunday night it was only of the third magnitude, and since that time it has gradually faded from sight of the naked eye. On Tuesday night it was taken note of at the Washington Observatory, and I suppose it is therefore not necessary for me to carry this memorandum any further.

ART. XIII.—*New and Brilliant Variable Star;* by B. A. GOULD.
(In a letter to the Editors dated Cambridge, June 9, 1866.)

ON Monday evening, May 14, Mr. S. C. Chandler, Jr., of the U. S. Coast Survey, while engaged in observing the magnitudes of fixed stars, by comparison without optical aid, perceived a brilliant star not a degree from ε Coronæ. At 11 P. M. he estimated its light as between that of β and γ Herculis, rather nearer to the latter; it was decidedly brighter than δ Boötis, and at least two-thirds of a magnitude brighter than β or γ Coronæ.

The sky had been obscured for several successive nights, but Mr. Chandler is confident that, three weeks previous (at which date he had examined the region with care), no star of sufficient brilliancy to attract attention was visible in this place.

On the ensuing evening, May 15, at 9 P. M., Mr. Chandler and myself examined the star together, and agreed in regarding its brilliancy as not essentially different from that of β Coronæ or γ Herculis, and as intermediate between the two. It was very manifestly fainter than δ Boötis.

The weather precluded further observations until May 19, on which evening the star had decreased by considerably more than two magnitudes, and was very near the limit of visibility to the naked eye. It was compared with several neighboring stars of similar brightness in Hercules and Serpens, both at 9^h and at 13^h; and in the interval between these comparisons it had diminished by not less than a tenth of a magnitude.

On the 20th, it was no longer perceptible by the unaided eye, but was easily seen and compared by means of an opera glass.

Subsequent observations have been made by Mr. Chandler and myself on the 24th, 28th, 31st May, and this evening, June 9; these being the only nights when the exceedingly unfavor-

able weather has permitted. Its magnitude this evening seems to be almost exactly the ninth.

The position of the variable was at once seen to correspond very nearly with that of a star, No. 2765 of 26°, given by Argelander in his "Durchmusterung des südlichen Himmels." An observation of position, by means of a transit-instrument belonging to the Coast Survey, and temporarily in my possession, corroborated the impression that these stars were identical; and now that the variable has waned to the 9th magnitude, and no other small star is found to have been obscured by its excess of brilliancy, it is manifest that the original suspicion was correct. There seems to be no regular observation of the star's place on record.

The determinations of magnitude during the time of visibility to the naked eye are rendered easy by means of a yet unpublished uranometry of the region between the declinations +45° and −2°, prepared at the Dudley Observatory in Albany during the year 1858, in which the brightness of every star visible to the naked eye is given to the nearest tenth of a magnitude. This, however, affords the numerical values for no date subsequent to May 19; and the comparison-stars for later observations are still subject to some uncertainty, which may affect the determination for the variable by a tenth or possibly by two-tenths of a magnitude. These will, however, be carefully determined before long by Mr. Chandler.

The Albany values for the brightness of the comparison-stars are these:

	M.		M.		M.
α Coronæ,	2·0	γ Herculis,	3·5	π Serpentis,	4·6
β Herculis,	2·3	β Coronæ,	3·5	B. A. C. 5399,	5·9
δ Boötis,	3·1	γ Coronæ,	3·6	Bessel Z. 296,3,	6·0
ε Herculis,	3·4	ε Coronæ,	3·9	B. A. C. 5452,	6·1

For the variable, the magnitudes, as thus far determined by us, are

		M.			M.
1866, May 14,	11^h	2·9	1866, May 24,	9½^h	7·8
15,	9	3·5	28,	10	8·9
19,	9	5·8	31,	10	8·9
"	13	5·9	June 9,	10	9·0
20,	9½	6·3			

Mr. Chas. A. Schott in Washington observed the star May 24 and 31, and estimated the magnitudes on those dates as 8·1 and 8·7 respectively.

Since first calling public attention to the sudden appearance of this remarkable star, I have received from many quarters information of its independent and, in several instances, previous detection; but only in a few cases do trustworthy determinations of its magnitude appear to have been made.

Mr. Wm. M. Davis, Jr., of Philadelphia, saw the star on the evening of May 12, called the attention of his family and friends to the phenomenon, and noted in his journal that the star was as bright as α Coronæ.

Mr. Ferguson, of the Washington Observatory, writes that the star was seen on Sunday evening, May 13, by Mr. Farquhar of Washington, assistant to Prof. Schaeffer, who communicated the fact to Admiral Davis, superintendent of the observatory. Mr. Farquhar estimated the magnitude on the 13th inst. as the second; Mr. Ferguson observed the star on the 15th, and estimated it as then of the fourth magnitude.

Prof. Watson, of the Ann Arbor Observatory, sends me word that Mr. Barker, a gentleman in London, Canada, perceived the star about May 1, and described it as equal to ε Coronæ in brilliancy at that time.

Prof. Henry Tutwiler, of Greene Springs, Ala., also detected the star on the 12th of May. For letters from him I am indebted to Robert Patterson, Esq., of Philadelphia, and to Prof. Henry of the Smithsonian Institution. He states that on that evening, it was somewhat superior in brilliancy to α Coronæ; and on other dates he observed or estimated it as follows: May 14th, 3d mag., somewhat brighter than β Coronæ; May 17th, less bright than ε Coronæ; May 19th, barely visible to the naked eye; May 20th, only perceptible through a small spy-glass, 8th mag.; May 24th, 10th mag. This last estimate must have been an extreme one, very possibly in hazy sky and without comparison-stars.

At an early day the star was also noted by Mr. Hallowell of Alexandria, who has very recently communicated his observations to a Philadelphia daily paper, but I have not yet been able to see them. Indirectly I have been informed that Mr. Hallowell has seen the star on previous occasions during the winter, which would imply that it has been fluctuating in short periods, since Mr. Chandler is positive that when he examined the region toward the close of April, the star was, to say the least, not conspicuous.

Mr. R. L. Knight, of Philadelphia, writes me that on the 23d of September last he saw, in the constellation of the Crown, a brilliant star, not laid down upon the maps, and that it was then equal to Gemma in brilliancy.

From these various data it would seem probable that the new variable which should, following Argelander's notation, receive the name *T Coronæ*, must have reached a magnitude of at least $1\frac{3}{4}$ at maximum, and that this maximum, perhaps only one of a series, occurred between the 5th and 12th of May.

P. S. June 12. The Astronomische Nachrichten of May 26, this day received, brings information of the detection of this star

in Ireland on the 12th, and in Rochefort, France, on the 13th of May.

On the 16th, Mr. Huggins and Prof. Miller made a careful observation of its spectrum,—the star being then a little below the 4th magnitude. Their inference was that the spectrum was double, consisting of one principal system of lines analogous to that of the sun; and, superposed upon this, a second one, apparently due to light emanating from intensely heated gaseous matter,—containing, among other bands, two bright ones in the positions of the lines F and C, which correspond to hydrogen lines.

Mr. Courbebaisse, who observed the star at Rochefort on the 13th, states that he had seen no such star there on the 11th.

ART. XIV.—*On the Emery Mine of Chester, Hampden County, Mass., with remarks on the nature of Emery, and its associate minerals;* by J. LAWRENCE SMITH, Pres't Louisville Gas Co.

CONSIDERABLE interest is attached to the recent developments of an extensive deposit of emery in Chester, Hampden county, Mass., by Prof. C. T. Jackson; and my name has been associated in various ways with it, without my having had any thing directly to do with it. Sundry communications have also been received by me from various parties. These communications are best answered by the facts embraced in this article, some portions of which it has always been my intention to publish without reference to the special interest of any one in the matter.

Prior to 1846, emery was simply known as a mineral, coming to us from a few remote localities, and was used in the arts without our having any knowledge of its true geological position or its mineralogical relations. About that period, circumstances favored my commencing those geological and mineralogical discoveries in relation to emery, that were afterwards embodied in two papers, presented to the Academy of Sciences of Paris, in 1850, in which the subject was thoroughly discussed, and I might say almost exhausted. The light in which those discoveries were considered will be seen by the conclusions of the report of the committee of the Academy, consisting of Messrs. Dufrenoy, Elie de Beaumont, and Cordier, viz:

"It results from the review just given of the labors of Dr. Smith, that he has made known—

1st. The precise nature of the geology of emery in Asia Minor and the Grecian Archipelago;"

2d. "That he has described the properties of the principal minerals associated with it, and the manner in which they occur,

especially diaspore and emerylite; this last mineral forms, by the identity of its composition in the different formations that the author had occasion to study, a mica constituting a new species, and one well determined;"

3d. "Finally, that he has given a means for determining the qualities of emery, and consequently their commercial value; this process, eminently practical, offers, besides, an interest in a scientific point of view, inasmuch as it permits of determining the difference in the tenacity of minerals of equal hardness.

"These researches of geology, mineralogy, and of analytical chemistry, constitute a work of the highest interest, both as a whole, as well as from the new facts they promise to science. Your committee consequently propose to thank Dr. Smith for having communicated them to the Academy, and in consideration of the importance of the work, to order the insertion of his paper in the *Receuil des Mémoires des Savants étrangers.*"

At that time I had discovered six new localities of emery in Asia Minor, and the Grecian Archipelago. Those localities were far removed from each other, and furnished so many different places for the study of emery and its associate minerals in addition to the old locality of Naxos; and consequently many points of general interest were brought out, besides others connected with the line of study. Those who may feel interested in the subject will find the investigation and results there arrived at in this Journal, vols. x and xi, 1850 and 1851; they embrace the geology, mineralogy, chemical composition, manner of mining, commercial considerations, associate minerals, &c.

The study of the associate minerals I considered of great importance, as they would be guides in future explorations in other parts of the world; and even prior to completing the researches on the subject I wrote to Professor Silliman and asked him to examine the American corundum localities for these minerals, one of them in particular, which he immediately did. With the corundum from the locality in Chester county, Penn., and Buncombe county, N. C., he "soon found the mineral indicated," and communicated the same to this Journal, Nov. 1849, pp. 379 and 383.

Nothing further came to my notice in relation to emery until I received from Prof. C. T. Jackson a letter dated Oct. 9th, 1864, containing what follows:

"You discovered emerylite or margarite in Asia Minor as an associate mineral with emery. On the 22d of October last, 1863, I discovered, while surveying an iron mine in Chester, Mass., some beautiful veins of the margarite, from half inch to two inches wide, and of a fine delicate rose color, or light pink. The nature of this mineral I did not discover until my return to Boston, but at first supposed it was lepidolite; on analysis it proved

to be margarite, and from that I ventured to predict the occurrence of emery, but no attention was paid to this prediction by the owners of the mine, who were more intent on the iron ore. A few weeks since, I saw Dr. Lucas, one of the owners, resident in Chester, and called him into my office, and explained to him the great value of emery, and told him how to detect it, and he promised to make the search I required, and took exact directions from me."

"The next day after his return to Chester, he found the emery, a big vein nearly six feet wide, which had been mistaken by him for iron ore, it being very magnetic. I write you this, to show you the importance of your discovery of the emerylite or margarite (for this appears to be identical), as an associate of emery, and also as an interesting case of deduction from scientific memoirs."

Accompanying the letter he sent me a paper giving me a summary of a communication he had made to the Boston Society of Natural History on the subject, concluding by remarking that "had not the occurrence of emerylite and chloritoid called his attention to the probable existence of emery at this locality, it would have been overlooked to this day, and no one knows how much longer. The fact was mentioned as an example of the real uses of supposed useless minerals; and the Doctor took occasion to express his obligations to Dr. Smith, of Louisville, for his valuable contributions to our knowledge of the associate emery minerals of the Grecian Archipelago and Asia Minor."

These statements are sufficient to show how far my geological observations served as a guide to Prof. C. T. Jackson, in his deductions with reference to the existence of emery in Chester, and with what diligence Dr. H. S. Lucas followed up the latter's directions, resulting in the valuable development of emery.

I have since visited the locality, having done so in the month of March last. The geological character and position of the rocks was not as well made out by me as might have been done in a more favorable season; but as my observations accord, as far as they go, with those of Dr. Jackson and Prof. Shepard, I prefer inserting their observations, rather than my own, in describing the geology of the emery locality.

"The mine is situated nearly in the center of the Green Mountain chain as it traverses the western border of the state, at a point not far from half way between the Connecticut and Hudson rivers. It is included in the metamorphic series of rocks, here consisting of vast breadths of gneiss and mica-slate, with considerable interpolations of talcose slate and serpentine. The general direction of the stratification is N. 20° E. and S. 20° W., the relation to the horizon varying from vertical, to a dip of from 75° to 80°, sometimes east, sometimes west.

"The immediate vicinity of the mine presents a succession of lengthened rocky swells with rather precipitous sides, having summits between 750 and 1000 feet above the level of the principal streams by which the hills are traversed. The longer axis of the elevations generally coincides with the directions of the strata.

"The emery vein traverses in an unbroken line the crests of two of these adjoining mountains, and scarcely deviates as a whole from the magnetic meridian. Each mountain is estimated to have a length of two miles, thus giving four miles extent to the metalliferous stratum, for such it may be truly called, consisting as it does so largely of the metals iron and aluminum. The Westfield river, here a small stream about four rods in width, flows directly across the northern end of the vein, dividing it into two equal portions. The height of each mountain is estimated at 750 feet.

"The emery vein, whose average width may be taken at four feet, is situated near the junction of the great gneiss formation constituting the western flank of the mountains with the mica-slate forming the eastern slope. To speak more exactly, however, it lies just within the gneiss, having throughout a layer of this rock of from four to ten feet in thickness for its eastern wall. Nor does the mica slate advance quite up to this outside layer of the gneiss; but in place thereof, an extensive intrusion of talcose slate occurs, having an average thickness of twenty feet on the south mountain, and widening out at the north mountain to a breadth of nearly 200 feet as it reaches the terminus of the vein, in the bed of the Westfield river.

"The gneiss, more especially in the vicinity of the vein, is a very peculiar rock. It abounds in thick seams of a coarse-grained, very black and shining hornblende; and where this is not found, it is much veined and penetrated by epidote. The stratification is much contorted also; and when the surface of the formation happens to be weathered or water-worn, its basseting edges strikingly resemble in color some of the serpentine marbles. It is also noticeable that in it quartz is everywhere singularly deficient. Traces of a white calcareous spar (calcite) are now and then visible upon the joints of the gneiss, with occasional specks of yellow copper, together with malachite stains; but no corundum, emery, or magnetite particles have thus far been detected as constituents of the gneiss. It is quite otherwise, however, with the talcy rock exterior to the wall of gneiss; for that formation in all its different varieties of talcose slate, soapstone, chloritic aggregates (with included seam of indianite), talcy dolomite, &c., which together constitute the stratum separating the gneiss from the mica slate, contain here and there disseminated grains of either emery, corundum, or magnetite; but,

like the gneiss again, are strikingly free from quartz or uncombined silica in any of its forms. Indeed this generally abundant substance is altogether wanting, not only in the emery-vein but in the talcose formations constituting its eastern boundary.

"It makes its appearance, however, in abundance in the mica slate as soon as the talcose rocks are passed—showing itself not only as the usual constituent of the slate, but in more or less continuous seams, from a few inches thick up to above six inches, and sometimes a foot, in width. Where the seams are thin and discontinuous, the included masses thin out at each end before disappearing, the sharp edges being curved in opposite directions, so as to form frequent white patches upon the surface of the rocks in the shape of the letter S."

Mineralogical Character and Composition of the Chester Emery.

It resembles more nearly that from Gumuchdagh (near Ephesus,) than any other that I know of. It is of a fine grain, and dark blue bordering on black, not unlike certain varieties of magnetic iron ore; with it there are frequently found pieces of corundum of some size. The interior of the mass is free from micaceous specks, such as are found in the emery of Naxos. Its powder examined under the microscope shows the distinct existence of more than one mineral, which are often so inseparably connected that the smallest fragments contain them together. The two predominating are *corundum* and *magnetic oxyd of iron*.

Several specimens were submitted to chemical examination from those most largely impregnated with magnetic oxyd of iron to those that appeared to contain least. They all consisted essentially of alumina and oxyd of iron; but I invariably found a little titanic acid and silica, and most commonly a minute quantity of magnesia. No. 1 was an inferior specimen; No. 2, the better quality of rock; No. 3, the emery rock crushed and prepared for market in the form of emery; No. 4, the same, and called emery crystals.

	1.	2.	3.	4.
Alumina,	44·01	50·02	51·92	74·22
Magnetic oxyd of iron,	50·21	44·11	42·25	19·31
Silica,	3·13	3·25	5·46	5·48

I examined a specimen of No. 2: grain fine, and treated repeatedly with hydrochloric acid and water over a water-bath: a great deal of oxyd of iron and a little alumina were dissolved; the residue on analysis proved to be nearly pure corundum, giving,

Alumina,	84·02
Magnetic oxyd of iron,	9·63
Silica,[1]	4·81

[1] No attempt was made to estimate the water.

All the chemical and physical examinations made go to show that the emery of Chester is, like all other emeries, a mixture of corundum and oxyd of iron; a fact that will be reverted to again a little farther on.

Prof. Jackson analyzed two specimens, after digesting them with nitro-muriatic acid, and has given as the composition,

	1.	2.
Alumina, - - - - - -	60·40	39·05
Protoxyd of iron, - - - - -	39·60	40·95

and then goes on to state, "from which it would appear that protoxyd of iron is an essential chemical ingredient in emery, and not an accidental admixture.[2] Dr. J. Lawrence Smith's experiments lead to the same result, but he considers the oxyd of iron to be an irregular mixture with the alumina and not a regular chemical constituent. In either case, I think emery ought to rank as a separate species, and not as a granular variety of corundum, from which it differs so in physical characters."

I would here remark that Dr. Jackson's conclusion would be correct in the first state of the case, were the iron an essential chemical ingredient; but in the latter, it would be erroneous, and introduce inextricable confusion into the science of mineralogy by admitting mere mechanical mixture as a specific distinction.

Prof. C. U. Shepard writing on the same point says, "His conclusions (Dr. Jackson's) would obviously be acquiesced in were it not for the strong resemblance in striæ and cleavage between the emery and common corundum, making it impossible for us to separate the substances crystallographically from one another. Nothing like a perfect crystal of emery has yet been found at the mine; but it is quite remarkable that the mineral is here generally coarsely massive, or in large separate individuals often of the size of kernels of Indian corn, whose cleavages are perfect, and which present on their planes the delicate striæ so characteristic of corundum from the Carnatic." Yet Prof. Shepard is for making emery a new mineral species and calling it *Emerite*, with the formula $\dot{F}e\ddot{A}l$.

If the views of Profs. Jackson and Shepard are to be taken as correct, the question as to the mineralogical position of emery is easily settled without resorting to any new mineral species. It is simply a massive iron-spinel (hercynite) with the anomaly of having a hardness equal to corundum.

	Iron spinel.	Emeries, Jackson.	Shepard.
Alumina, - -	58·75	60·49	$\ddot{A}l\dot{F}e$
Protoxyd iron, -	41·25	39·60	

I would say, at this point, that if the mineral of Chester is to be regarded as an aluminate of iron, the rock called emery

[2] An examination of my analyses in 1850, which it is supposed are the ones referred to here, most certainly do not sustain the conclusion.—J. L. S.

coming from Naxos and other well known localities is not that compound, *and that if one is emery the other is not.* But as I do not take their view of the matter, *I consider the Chester mineral as true an emery as that of Naxos.*

As there seems to be some mistake and incorrect quotation in regard to my analyses of emery and corundum, I reproduce the tabular statement of the analyses, and effective hardness, referring the reader to the original paper for a correct view of what is understood by the effective hardness.

No.	Locality.	Effective hardness Sapphire 100.	Specific gravity.	Composition.				
				Water.	Alumina.	Magnetic oxyd of iron.	Lime.	Silica.
	EMERY.							
1	Kulah, ...	57	4·28	1·90	63·50	32·25	0·92	1·61
2	Samos, ...	56	3·98	2·10	70·10	22·21	0·62	4·00
3	Nicaria, ...	56	3·75	2·53	71·06	20·32	1·40	4·12
4	Kulah, ...	53	4·02	2·36	63·00	30·12	0·50	2·36
5	Naxos, ...	46	3·75	4·73	58·53	24·10	0·86	3·10
6	Nicaria, ...	46	3·74	3·10	75·12	12·06	0·72	6·88
7	Naxos, ...	44	3·87	5·47	69·46	19·08	2·81	2·41
8	Ephesus, ...	42	4·31	5·62	60·10	33·20	0·48	1·80
9	Kulah, ...	40	3·89	2·00	61·05	27·15	1·30	9·63
	CORUNDUM.							
1	Sapphire of India,	100	4·06	....	97·51	1·89	....	0·80
2	Ruby " "	90	....	....	97·32	1·09	....	1·21
3	Corundum, Nicaria,	77	3·88	1·60	92·39	1·67	1·12	2·05
4	" Asia M.,	65	3·92	0·68	87·52	7·50	0·32	2·01
5	" Asia,	60	3·60	1·66	86·62	8·21	0·70	3·85
6	" India,	58	3·89	2·86	93·12	0·91	1·02	0·96
7	" Asia,	57	3·80	3·74	87·32	3·12	1·00	2·61
8	" India,	55	3·91	3·10	84·56	7·06	1·20	4·00
	EMERY.							
1	Chester, Mass., ...	33	....	....	44·01	50·21	....	3·13
2	" "	40	....	....	50·02	44·11	....	3·25
3	" "	39	....	....	51·92	42·25	....	5·46
4	" "	45	....	....	74·22	19·31	....	5·48
5	" "	..	....	....	84·02	9·63	....	4·81

By the above it will be seen that the magnetic oxyd of iron in the emery of Naxos, Ephesus, &c., varies from 13 to 33 per cent, the water from 1·9 to 5·0 per cent, the silica from 1·6 to 9·6 per cent. All of these ingredients form minerals apart from the corundum, which is represented by the principal portion of alumina. Some of the alumina found in the analysis is associated with the above ingredients to form associate minerals which have been fully studied. This last will serve to explain why it is that emeries having the same amount of alumina may have different degrees of effective hardness. Thus: Nos. 9 and 4, both Kula emeries, containing about the same amount of alumina, have effective hardness in the proportion of 40 to 53; but it will be seen that No. 9 contains 9·6 per cent of silica, which doubt-

less appropriates a portion of the alumina, thus reducing the alumina attributable to corundum; so that, were it possible to ascertain the exact amount of corundum present in 9 and 4, it would doubtless be in proportion to their effective hardness. So again, if we compare Nos. 8 and 1, the effective hardness will be found in the proportion of 42 to 57, while their amounts of alumina vary only as 60 to 63; but if we regard the amount of water in the two it is as 5·6 to 1·9, much of this water coming from diaspore that is intimately mixed with the corundum; and in several specimens I possess, the two minerals shade into each other so completely, that it is impossible to tell where one begins and the other ends. The above facts were all well examined when my first memoirs appeared on this subject, which accounts for the following remark then made:

"Those emeries which contain the least water, everything else alike, are the hardest, as instanced by that from Kulah, notwithstanding the quantity of iron it contains. The silica existing in emery is most often in combination with alumina, or the oxyd of iron, or both; for this reason we must not always regard the quantity of alumina as an indication of the quantity of corundum in emery."

In concluding this part of the subject I would state that while I do not consider my opinions infallible in this matter, still all my experience and research, gathered from such varied sources, point to the conclusion that emery is a mixture of several minerals, principally corundum and magnetic oxyd of iron, the former being the effective agent in the mechanical abrasion to which it is applied; the oxyd of iron is not to be considered as an unimportant ingredient, it serving by its presence to destroy to some extent the harsh cutting action of the corundum.

Minerals associated with the emery of Chester.

Corundum.—This mineral, as might naturally be expected, is found with the emery, sufficiently distinct and separate to be at once recognized, sometimes in thin seams, massive in its character, but more commonly in flattened crystals of small dimensions.

Diaspore.—Very excellent and beautiful specimens of this hydrate of alumina have been found at this emery locality; it is often in distinct and separate prismatic or bladed crystals, quite colorless and transparent.

Emerylite or Margarite.—Some of the finest specimens of this mineral that are known have been found at this locality. It will be seen by referring to my former papers on emery, that I first discovered this mineral associated with emery; its composition showed it to differ from any other then known mineral. I compared it subsequently with margarite, which had been discovered before, and suspected the identity of the two minerals;

but as the analysis made out and accepted as the composition of margarite did not accord with that of emerylite, I undertook to reëxamine margarite, when I found that its composition had been erroneously determined, and that it was, in fact, the same mineral with emerylite, which last name has had to yield to the priority of date of the other.

I have analyzed the margarite from Chester and find its composition as follows:

Silica,	32·21
Alumina,	48·87
Lime,	10·02
Oxyd of iron,	2·50
Manganese,	·20
Magnesia,	·32
Soda and little potash,	1·91
Lithia,	·32
Water,	4·61

There is a little titanic acid with the oxyd of iron that I did not estimate.

Chlorite.—This mineral as found with the emery is the so-called *corundophilite* of Shepard; on examination it proves to be, both chemically and physically, a chlorite of the variety ripidolite.

Biotite.—In examining a specimen of dark green micaceous mineral which I took to be chlorite (the corundophilite of Shepard) and from its purity expected to get a very accurate idea of its composition, but in the very commencement of the examination it was discovered to be well characterized *biotite.*

This mineral occurs on the surface of a white rock that Prof. Shepard calls indianite, but which I have not had time to examine. It is in small thin micaceous crystals perpendicular to the surface of the indianite; in the mass, it is of a dark green color, so dark that at a little distance it looks like lamellar plumbago. A careful analysis gave the following composition:

Silica,	39·08
Alumina,	15·38
Magnesia,	23·58
Peroxyd of iron,	7·12
Manganese,	·31
Potash,	7·50
Soda,	2·63
Water,	2·24
Fluorine,	·76
	98·60

This corresponds with the composition of the biotite from Monroe county, New York, as made out by Prof. Brush and myself in our reëxamination of American minerals several years ago.

Corundophilite proved to be a chlorite.—About the time I published my memoirs on emery in 1850 and 1851, Prof. Shepard made the announcement of a new mineral (this Journal, 1851, xii, 211), stating that it "occurs with corundum near Asheville, in Buncombe Co., N. C., in imperfect stellate groups, and also spreading out in laminæ between layers of corundum; color leek-green, etc." An analysis of it afforded silica 34·76, protox. iron 31·25, alumina 8·55, water 5·47, *making a loss of nearly* 20 *per cent, a portion of which he attributes to alkalies;* neither lime nor magnesia were detected. He operated on 140 milligrams; this mineral was considered a new one, and Prof. Shepard called it corundophilite. Supposing that I had observed the same mineral in certain specimens of emery and emerylite from Chester, Mass., I enclosed a fragment of the specimen to Prof. S. to ascertain if this was the mineral he called *corundophilite;* he returned the specimen, announcing that it was. I then analyzed the same and found it to be, both chemically and physically, a chlorite, identical no doubt with the chlorite I found associated with the emery of Asia Minor; both the Asia Minor and Chester varieties occur in compact mass, composed of an agglomeration of small crystalline plates—identical with the chlorites of Mont des Sept Lacs and of St. Christophe, and the ripidolites of Rauris and St. Gothard. In the following analysis I do not pretend to furnish that of the pure mineral, as from the thinness of the layers in the specimens at my disposal it cannot be separated in that state of purity I am in the habit of seeking for in all minerals that I examine:

Silica,	25·06
Alumina,	30·70
Protoxyd of iron,	16·50
Magnesia,	16·41
Water,	10·62
	99·29

The optical characters were not examined, there being no means at hand.

I may remark that the alumina and magnesia were separated by resolution and reprecipitation three times.

Tourmaline.—This mineral is also found with the emery of Chester in the same manner as with the emery of Naxos.

Titaniferous iron (ilmenite).—This is found principally in flattened crystals in the margarite.

Oxyd of titanium (brookite or rutile).—With the diaspore we found some beautiful flattened hair-brown crystals; the specimen in my possession does not furnish the face of the crystals so as to enable me to make out what form of titanium oxyd it is. Prof. Shepard thinks he has sufficient evidence to pronounce it to be brookite.

Magnetic oxyd of iron.—This ore of iron is found in great abundance associated with the emery, and is worked for the manufacture of iron; it contains a little oxyd of titanium.

The above, as well as some other associated minerals of less importance, justify the concluding remarks of my paper on emery fifteen years ago, viz: "I do not risk much in saying that the hydrate of alumina or diaspore, as well as the silicate or emerylite, chlorite or tourmaline, and the minerals of iron, as magnetic, titaniferous iron, &c., will be found almost everywhere with the emery and corundum."

ART. XV.—*On some minerals associated with the Cryolite in Greenland;* by G. HAGEMANN.

A NOTICE of the pachnolite, discovered by Prof. Knop in the Greenland cryolite, has already appeared in this Journal.[1] On examination of several cargoes of cryolite imported by the Pennsylvania Salt Manufacturing Company, I have not only found pachnolite, but also have observed some other minerals which may be of interest.

Dimetric Pachnolite.—Among these is a mineral first observed by Prof. Julius Thomsen of Copenhagen, the originator of the cryolite industry. As I am informed, he found a mineral, which on a preliminary examination he thought might prove a fluorid of silicon compound, but I have not heard of any further investigation of the substance. In looking over the cargoes of cryolite I have found a mineral which I believe to be the same with that noticed by Prof. Thomsen.

The mineral crystallizes in dimetric form, the dimetric pyramid and prisms being plainly seen, but no further crystallographic examination was made. It has a distinct basal cleavage. The color is white with a reddish tinge, the crystals have a bright luster, and are coated with a white earthy envelop ($\dot{S}i\dot{f}$). Sp. gr., 2·74–2·76; hardness, about that of cryolite. Heated in the closed tube this mineral yields water with an acid reaction which etches the glass. At a higher temperature it melts to a clear glass, fusing even more readily than cryolite. When pulverized it is easily decomposed by sulphuric acid, and on qualitative analysis it proves to contain water and fluorine, aluminum, calcium, sodium, and some silica. In the quantitative examination it was found extremely difficult to separate the alumina from the lime when precipitated by ammonia from the solution in sulphuric acid. I redissolved and reprecipitated six times before obtaining a complete separation. The water was determined by heating the mineral with previously ignited

[1] Vol. xli, p. 119.

quicklime. The fluorine was determined as fluorid of calcium by decomposing the mineral with a mixture of silica, and the carbonates of potash and soda. After the soluble fluorids were separated from the insoluble silicates, alumina and silica were separated by carbonate of ammonia, and fluorid of calcium with carbonate of lime were thrown down with chlorid of calcium; this precipitate was dried and ignited, and the carbonate of lime was removed by acetic acid. The silica was imperfectly determined, as I had not the means at my disposal to estimate it accurately. I treated the pulverized mineral with solution of soda and carbonate of soda, filtered, and decomposed the solution by chlorhydric acid; evaporating to dryness thus rendering the silica insoluble. Analysis gave,

		Equivalents.	
Fluorine,	50·08	2·63	
Aluminum,	14·27	1·05	
Sodium,	7·15	0·311	1·036
Calcium,	14·51	0·725	
Water,	9·70	1·07	
Silica,	2·	0·135	
	97·71		

The formula is very near $Al_2Fl_3 + 2(\frac{2}{3}Ca + \frac{1}{3}Na)Fl + 2HO$, which corresponds closely with Knop's formula for pachnolite, $Al_2Fl_3 + 3(\frac{3}{5}Ca + \frac{2}{5}Na)Fl + 2HO$. I scarcely know how to place the silica, but I think it does not really belong to the compound.

Arksutite.—This is a white crystalline granular mineral with a high luster. No crystals were observed, but each grain shows at least one good cleavage. Sp. gr., 3·029–3·175, (variation probably caused by minute crystals of iron-pyrites). Hardness, the same as cryolite. Fuses at a red heat without giving off water. Analysis gave,

Fluorine,	51·03	2·68		2
Aluminum,	17·87	1·307		1
Sodium,	23·00	1·	1·35	1
Calcium,	7·01	0·35		
Moisture,	0·57			
Insoluble,	0·74			
	100·22			

Hence the compound gives the formula $Al^2Fl^3 + 2(Ca,Na)Fl$. I hope in time to find a series of these fluorids which will, perhaps, show how cryolite is decomposed into pachnolite, and this may be still further altered into what the Greenlanders call "natural soap," (a hydrate of alumina?). Both these minerals are found associated with cryolite in the vicinity of Iviktant near Arksut-fiord, in South Greenland.

Natrona, Pa., May, 1866.

ART. XVI.—*Evidence of Two distinct Geological Formations in the Burlington Limestone;* by W. H. NILES and CHARLES WACHSMUTH.[1]

DR. CHARLES A. WHITE was the first to record any natural division of the Burlington limestone. In the Journal of the Boston Society of Natural History, vol. vii, No. 2, Dr. White has given a "Section of rocks exposed at Burlington." He there describes eight beds, which he numbers from the lowest upward. He refers the first six beds of his section to the Chemung group, and beds "No. 7" and "No. 8" to the Burlington limestone. In vol. ix of the Proceedings Bost. Soc. Nat. Hist., and in No. 4 of the Journal of the same society, Dr. White describes certain species of fossils from the Burlington rocks; and although he gives the beds or divisions in which the species occur, yet nowhere does he claim that the Burlington limestone comprises more than one geological formation.

Our own observations have led us to regard these two divisions of the Burlington limestone as two distinct geological formations. The lower division we call the Lower Burlington limestone, and the upper division, the Upper Burlington limestone. The reasons for ranking these divisions as distinct formations are as follow:

The Burlington limestones are eminently crinoidal in their composition, as well as in their better preserved fossils. While fragments of these remains form an important feature in the greater mass of these rocks, there are, likewise, some strata of considerable thickness, which are composed almost entirely of

[1] While making a special study of a family of Crinoids, the Actinocrinidæ, the results of which were to have published in the Illustrated Catalogue of the Museum of Comparative Zoology, it became necessary to spend considerable time at Burlington, Iowa, for the purpose of studying the large and valuable collections of Mr. Charles Wachsmuth, Rev. W. H. Barris, and Dr. Otto Thieme. From the published observations of Dr. C. A. White, and from some notes made by Mr. Wachsmuth, I had been led to believe that a careful study of the distribution of the crinoidal remains at Burlington would be rewarded with interesting paleontological results. I found Mr. Wachsmuth acquainted with many important facts in this connection, which could be reached only by a long experience in collecting these fossils, by an intimate acquaintance with the species, and a series of most careful observations. Accordingly, with the consent of Prof. Agassiz, I associated myself with Mr. Wachsmuth, for a careful examination and comparison of all the specimens in the three collections, for the identification of the species, and for the determination of their stratigraphical position; with the intention of publishing, in some scientific journal, such results as were of scientific interest.

We now give only a preliminary notice of some of the results of our study, designing to extend our investigations to more southern localities, where the Burlington limestone is exposed. In a future paper, we shall present a complete catalogue of all the described species of Crinoids occurring in these limestones, with notes upon their geographical distribution, their stratigraphical range, and the rarity or frequency of their occurrence. W. H. N.

these fragments. We know about three hundred species of these fossils from the immediate vicinity of Burlington alone. These species represent twenty-four recognized genera, and were they classified according to their zoölogical characters the number of the genera would be considerably increased. Considering the age and the highly fossiliferous nature of these strata, the Mollusca, even the Brachiopoda, are represented by comparatively few fossil forms.

The evidence that crinoids were the reigning forms of animal life in the waters of that ancient sea which deposited these limestone strata is of the most satisfactory nature. It is, therefore, to these animals that we ought to refer, for that evidence of organic change and progress characteristic of different periods in geological history. Such an organic change and progress is distinctly marked in the crinoidal remains of the Burlington limestones, and it is upon such evidence that we found our classification of these strata.

The strata of the Lower Burlington limestone present many differences in color, structure, and composition; but by intimate acquaintance they can generally be distinguished from those of the Upper Burlington limestone by their lithological characters alone. In the upper part of this formation the limestone strata become interstratified with beds of chert, and the uppermost stratum of chert, which attains any considerable extent and thickness, forms the division between the Lower and the Upper Burlington limestones. This stratum of chert, in the vicinity of Burlington, is from two to three feet in thickness. The Crinoids found below this stratum of division, are, in the aggregate, of smaller size than those above it; they are not so coarse in their general features, and their ornamenting ridges, nodes and spines, never assume that striking prominence exhibited in many species of the Upper Burlington limestone.

These features distinctly show that, during the deposition of these strata of the Lower Burlington limestone, the circumstances were less favorable to the extraordinary growth of these animals than they were during the time represented by the Upper Burlington strata. A similar, but not a more marked distinction of general features, is to be noticed between the crinoids of the Upper Burlington and those of the Keokuk limestone; as it appears from the fossils, that it was during the latter formation that crinoids culminated in extravagance of size and features. Three grades of crinoidal development are thus exhibited: by the species of the Lower Burlington, those of the Upper Burlington, and by those of the Keokuk limestone.

We have examined the species of Crinoids and noticed their stratigraphical distribution with care, and have found no evidence of any species occurring in both the Lower and the

Upper Burlington limestones. It would seem, from these facts, that there was something connected with the presence of siliceous matter in depositing waters, during the formation of the upper beds of the Lower Burlington Limestone, which was unfavorable to the growth and life of the inhabiting Crinoids; for, with the introduction of the chert deposits, the Crinoids appear to have declined, and finally all of the species became extinct before the completion of the dividing stratum of chert above mentioned. A parallel instance is to be noticed in the fact that there is a stratum of chert between the Upper Burlington and the Keokuk limestones, which marks a similar organic change and progress.

There was also a great change in the Mollusca, as most of the species of the two divisions are distinct.

We here give lists of some of the better known species of Crinoids, arranged under the names of the formations to which they are exclusively restricted. We are also acquainted with many undescribed species, which are as distinctly limited to one formation as those here mentioned.

Some species of Crinoids which are found only in the Lower Burlington Limestone.

Actinocrinus proboscidialis Hall.
multibrachiatus "
sexarmatus "
thetis "
ornatus "
inflatus "
sculptus "
discoideus "
turbinatus "
papillatus "
formosus "
inornatus "
lepidus "
aequalis "
opusculus "
chloris "
clarus "
infrequens "
lucina "
thoas "
ovatus "
cœlatus "
gemmiformis "
corbulis "
coronatus "
clio "
carica "
pentagonus "
unispina "
subaculeatus "
excerptus "
spinobrachiatus "
Actinocrinus divergens Hall.
superlatus "
brevis "
unicornis Owen & Shumard.
araneolus Meek & Worthen.
Agaricocrinus corrugatus Hall.
planoconvexus Hall.
Megistocrinus Evansii Owen & Shumard.
Whitei Hall.
Platycrinus planus Owen & Shumard.
Yandellii "
corrugatus "
discoideus "
Burlingtonensis "
Prateni Worthen.
ornogranulus McChesney.
scobina Meek & Worthen.
verrucosus White.
regalis Hall.
eminulus "
parvinodus "
pileiformis "
subspinosus "
pocilliformis "
nucleiformis "
truncatulus "
exsertus "
calyculus "
cavus "
truncatus "
sculptus "
clytis "

Platycrinus excavatus Hall.
striobrachiatus "
nodobrachiatus "
Cyathocrinus Wachsmuthi Meek & Wor.
Iowensis Owen & Shumard.
cornutus "
rigidus White.
malvaceus Hall.
divaricatus "
solidus "
latus "
macropleurus "
Poteriocrinus aqualis "
calyculus "
subimpressus M. & W.
enormis "
Scaphiocrinus simplex Hall.
spinobrachiatus "
Scaphiocrinus ramulosus Hall.
tortuosus "
Wachsmuthi M. & W.
solidus "
Cœliocrinus dilatatus White.
Ichthyocrinus Burlingtonensis Hall.
Bursacrinus confirmatus White.
Forbesiocrinus Thiemei Hall.
Rhodocrinus Wortheni "
Wachsmuthi "
Whitei " [Hall.
" var. Burlingtonensis
Trematocrinus reticulatus Hall.
fiscellus "
Zeacrinus scoparius "
Pentremites stelliformis O. & S.
melo "
" var. projectus M. & W.

Some species of Crinoids which are found only in the Upper Burlington Limestone.

Actinocrinus umbrosus Hall.
ægilops "
rudis "
insculptus "
tholus "
althea "
regalis "
glyptus "
perumbrosus "
ventricosus "
verrucosus "
rusticus "
glans "
calyculoides "
clœlia "
quinquelobus "
trinodus "
cornigerus "
decornis "
symmetricus "
subturbinatus M. & W.
asteriscus "
Koninckı Shumard.
Verneuilianus "
Missouriensis "
multiradiatus "
subventricosus McChesney.
Wachsmuthi White.
Nashvillæ var. subtractus W.
Hageri McChesney.
Christyi Shumard.
pyriformis "
rotundus Yandell & Shum.
dodecadactylus M. & W.
oblatus Hall.
amplus M. & W.
Megistocrinus plenus White.
Agaricocrinus pentagonus Hall.
ornatrema "
Agaricocrinus excavatus Hall.
bullatus "
stellatus "
geometricus "
gracilis M. & W.
Platycrinus olla Hall.
glyptus "
tuberosus "
subspinulosus "
Wortheni "
quinquenodus White.
pleurovimenus "
asper Meek & Worthen.
incomptus White.
Dichocrinus plicatus Hall.
scitulus "
liratus "
lachrymosus "
striatus Owen & Shumard.
angustus White.
crassitestus "
Synbathocrinus dentatus O. & S.
Wortheni Hall.
papillatus "
Cœliocrinus subspinosus White.
Cyathocrinus viminalis Hall.
rotundatus "
sculptilis "
lamellosus White.
Poteriocrinus ob-uncus "
salignoideus "
Swallowi M. & W.
tenuibrachiatus "
carinatus "
Scaphiocrinus rusticellus White.
carinatus Hall.
Halli "
Rhodocrinus Barrisi " [Hall.
" var. Burlingtonensis

Trematocrinus typus Hall.	Cheirocrinus dactylus Hall.
tuberculosus "	ventricosus "
papillatus "	lamellosus "
Pentremites Norwoodi Owen & Shum'd.	Belemnocrinus typus White.
elongatus Shumard.	Bursacrinus Wachmuthi Meek & Wort'n.
Sayi "	Zeacrinus elegans Hall.
sirius White.	ramosus "
Forbesiocrinus Agassizi Hall.	perangulatus White.
asteriæformis "	sacculus "
ramulosus "	Troostanus Meek & Worthen.

ART. XVII.—*On a proposed Printing Chronograph;* by C. A. YOUNG, Prof. Nat. Phil. and Ast. in Dartmouth College.

EVERY astronomical observer who has used the ordinary forms of chronograph knows that at least as much labor is expended in measuring up the sheets, and putting the record into figures, as in making the observations; to say nothing of the fact that the operation involves an opportunity for accidental errors very vexatious and hard to trace.

It is proposed to save the whole of this purely clerical labor by making the chronograph itself record the instant of observation in hours, minutes, seconds and hundredths of a second, in printed characters, and in a form suitable for preservation and reduction.

This idea occurred some years ago to Mr. Hilgard of the Coast Survey, and at a recent meeting of the National Academy he read a description of an apparatus designed to realize it. Prof. Hough of the Dudley Observatory has also done something toward a solution of the same problem. The plan about to be proposed, however, differs from both of theirs, and was substantially devised nearly a year ago, previous to any knowledge that others were at work on the same subject.

Mr. Hilgard's invention undoubtedly possesses more of novelty and theoretical beauty; in practical accuracy there would be no difference, as either secures a record correct to the nearest hundredth of a second; in simplicity and cheapness of construction, certainty of operation, and security against derangement, the advantage is probably with the apparatus whose description follows.

The well known spring-governor of Professor Bond is taken as the basis of the instrument. The wheel-work should, however, be made much heavier than ordinary, and especially the centrifugal fly should be of sufficient size and weight to answer the purpose of a balance wheel in preventing sensible changes of velocity from slight momentary variations in the resistances of the train.

The pendulum should be controlled by electro-magnetic impulses sent every second from the standard clock, in the same

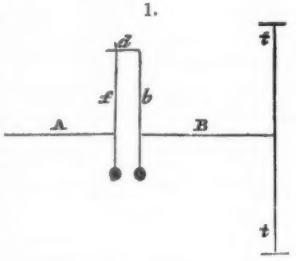
manner practised for some years at the Dudley and other observatories. It might perhaps be well to substitute for the half seconds pendulum commonly used, a pendulum beating quarter seconds, the requisite rapidity of oscillation being secured by a spring.

I think that the experience of observers with the spring-governor chronograph warrants the belief that the irregularities of motion need never, in a well made instrument, cause errors of more than one, or at most two, one-hundreths of a second, the pendulum of the apparatus being under the control of the clock in the way above mentioned.

I shall assume then that we have an axis revolving once per second with a uniform motion. It is immaterial, of course, whether this uniform motion is obtained through the spring-governor, or by means of some other of the many ingenious inventions that have been contrived for the purpose, though I do not think any can be found more simple and effective.

Suppose now that in fig. 1, A is such an axis, and that B is a second axis mounted on the prolongation of A, but entirely separate, bearing a type-wheel, *t t*, at its extremity. Suppose also that *f* is a balanced arm attached to the extremity of A, and that *b* is a similar arm attached to B, and bearing a pin, *d*, which engages with *f*.

1.



It is then evident that A in its motion would take along the type-wheel, *t t*, in precise coincidence with itself. If now, at the instant of observation, it were possible to remove the pin *d*, the type-wheel might be stopped, an impression be obtained of whatever figures were uppermost, and then, the pin being replaced, at the next revolution the arm *f* would encounter it and again put the type-wheel in motion as before.

By this operation the arbor A would have been subjected to the two following disturbances: 1st, during one second (for the time of making the imprint need never exceed a fraction of a second) it would be relieved of whatever friction might be due to the revolution of B. This relief from friction would tend to acceleration: 2d, at the instant when the arm *f* strikes the pin it will receive a shock due to the inertia of B and its appendages; this would tend to retardation. The difference only of the two effects would have to be corrected by the action of the spring-governor; and it is believed, if the governor train has considerable momentum, and the type-wheel *t t* is made as light as possible, that the disturbance will be nearly or quite insensible.

The mechanical arrangements by which this idea is carried

out are more fully represented in figure 2, which is drawn of the actual dimensions proposed. It represents a vertical section through the plane of the seconds-axis A. This is made to project about half an inch through the front plate of the chronograph frame, and carries a spiral cam, *a*, and an arm, *b*. The cam acts upon the end of a lever (not shown in the cut) which, by a ratchet movement, causes the wheel L, near the right of the figure, to advance one step at the end of every second.

The type-wheel K, which indicates the seconds, is connected with L by a spring. This spring comes into action only when the hammer happens to be down on the face of K (in the act of printing an observation) at the same instant that the lever, dropping off from the end of the spiral *a*, is urging the wheel forward. Were it not for the intermediate wheel L and the connecting spring, a second might be lost in the indication of the type-wheel K on such an occasion. As it is, the wheel L will move on to its proper place, bending the spring a little, and as soon as the hammer rises K will also be carried forward by the spring.

A cam, M M, on the wheel L drives the minute-wheel N by a similar lever and ratchet; and the hour-wheel, if it is thought worth while to have one, is to be driven from the minute-wheel in the same way.

It would be better perhaps to relieve the arbor A from the work of driving the second and minute wheels, by using for the purpose a separate clock movement controlled magnetically by the standard clock, as proposed by Prof. Hough; but this would involve considerable additional expense.

The type-wheel *t t* is mounted upon its axis B B, in the prolongation of A, its bearings being ivory boxes, represented at *h* and *h'*. This type-wheel is made as light as possible; the vertical portion is of steel as thin as is consistent with strength, while the rim is a thin strip of copper soldered to the steel disc, and bearing in raised type the figures 00, 02, 04, 06, &c., up to 98. The copper strip may be made by the electrotype process from a leaden matrix in which the figures have been sunk at proper intervals by a common type punch.

As this rim would be hardly stiff enough to print from without some support, the bearing *h* is held to its place by a spring little more than strong enough to support the weight of the wheel; when the hammer descends to make an imprint this yields a little, and allows the rim of the wheel to come down upon the bed F.

The wheel *t t* is adjustable upon its axis so that its zero can be made to come uppermost at the instant when the wheel K effects the change of the indicated second.

The type-wheels K and N are constructed in the same way, only their rims are made heavy enough to print without any support except that afforded by the disc of the wheel.

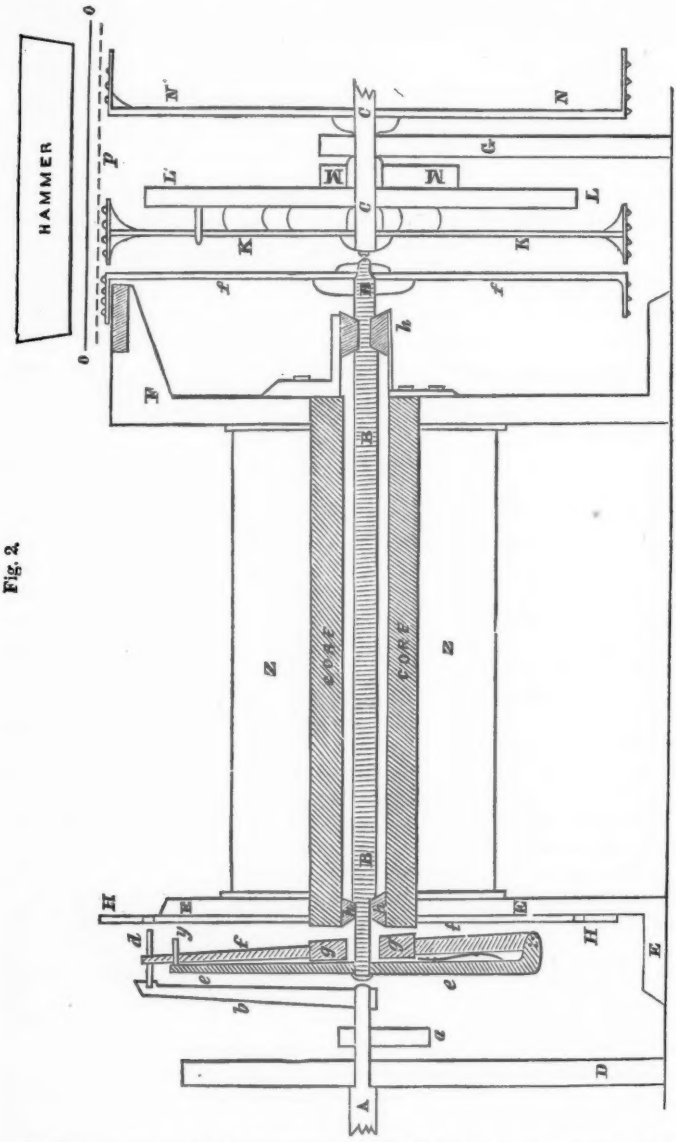


Fig. 2.

The arm *e e* is firmly secured to the left-hand extremity of the axis B, and carries at one end two pins (*y*) near each other,

forming a fork; at the other end it has a little projection (x). The arm ff is delicately pivoted at (x), and at the other extremity passing freely between the pins of the fork (y) carries the steel pin d. At the middle it is expanded into a ring, gg, through which the arbor B passes without touching: ff is made of soft iron, and the annular expansion at the middle thus serves for the armature of the electro-magnet whose action is to produce the desired result at the touch of the observer's key.

A light spring between e and f solicits f to the left, and thus whenever the electro-magnet is not acting keeps the pin d in the position represented in fig. 2, engaged with the arm b. In this state of things the type-wheel tt will be carried round continuously by A. Of course the arms e and f must be as light as consistent with sufficient stiffness, and their weight must balance in all parts of the revolution, and neither tend to accelerate or retard the motion of the type-wheel.

Close behind the arms e and f is placed a stationary disc of metal, H H, having one hundred equidistant holes pierced in it in a circle, so situated that whenever the arm f is drawn to the right by the magnet (thus disengaging the type-wheel from the train) the pin d will immediately enter one of these holes, stop the type-wheel, and hold it in place until the magnet ceases to act.

This magnet is peculiar in having for its core, instead of a solid rod, an iron tube, through which the axis B passes. Thus the pole of the magnet is always in the same position with reference to the armature gg, notwithstanding its revolution. As only one pole of the magnet acts upon the armature it is necessary to make the coils more powerful than ordinary.

For bringing the hammer down upon the paper and moving the paper along after each impression any one of many different plans might be used. Probably the best, leaving expense out of the account, would be to have the hammer raised by an independent train of wheelwork, which should be unlocked by an electro-magnet at the instant of observation, thus releasing the hammer, and allowing the wheelwork after the blow to move far enough to raise the hammer again, and carry the paper forward.

Another more simple plan is to work the hammer directly by a powerful electro-magnet, to which the magnet Z should act as a relay—that is, whenever the pin d touches the disc H it should establish a current which should bring down the hammer upon the paper; the hammer in rising after the blow carries the paper along one space.

Provision is also made for carrying the paper along several spaces at the will of the observer, so as to leave an interval between the record of different stars.

Although there are only fifty numbers on the type-wheel which prints the decimal of the second, the record is made to the nearest hundredth. There being one hundred holes in the

disc H, the type which indicates the decimal of the second may either come in line with that which gives the whole seconds, or half a space above it, thus: 25·18 or $25^{\cdot 18}$; the first would be read twenty-five and eighteen hundredths, the second twenty-five and nineteen hundredths.

It is not intended to secure precise coincidence of *error* between the clock and chronograph—merely coincidence of *rate*. This is obtained by controlling the pendulum of the spring-governor from the clock. The type-wheels can be set so as to indicate the nearest whole second; and then the exact difference between the clock error and the chronograph error can easily be found by making the clock record itself occasionally at the beginning of a minute.

The operation of the instrument is then as follows. When the observer touches his key, the magnet Z acts upon the armature, and withdraws the pin *d* from its engagement with *b*, causing it to plunge into one of the hundred holes in the disc H. The contact of *d* with H in its turn, by a magnet not shown in the cut, brings down the hammer upon the paper *o o* and forces it against the type, a piece of impression paper being interposed.

When the observer takes his finger from the key, *d* returns to its original position and will engage with *b* at its next revolution. The hammer also rises, and in rising carries the paper along one space in readiness for the next impression.

As yet the printing chronograph exists only as an idea, but it is hoped that the idea will soon be realized, and the machine put in operation at the Shattuck Observatory. The result of the experiment will form the subject of a future communication.

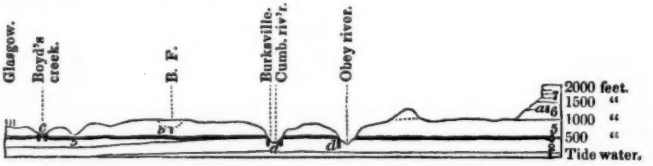
Dartmouth College, April, 1866.

ART. XVIII.—*Note on the geological position of Petroleum Reservoirs in Southern Kentucky and in Tennessee;* by Prof. J. M. SAFFORD.

THE object of the following note is to point out briefly the geological position of the petroleum reservoirs in Southern Kentucky and in Tennessee, so far as they have been met with within the field of my observations. I hope, in a future article, to give a summary of all ascertained facts with reference to the mineral oils of this region.

The accompanying general section will serve to illustrate the topographical and geological features of the region under consideration. The line of section extends from the Cumberland mountain, or table-land, in Putnam county, Tennessee, through Overton county, in a direction a little west of north, to Burksville, Kentucky, and thence to Glasgow. The entire distance is

about seventy miles. The region traversed by this line is a plateau, from 800 to 1000 feet above the sea, out of the nearly horizontal strata of which the larger streams have eroded valleys from 300 to 500 feet deep.



The following are the formations represented in the section:

7. *Coal-measures*, 400 ft., edge of table-land.

6. *Mountain Limestone*,[1] about 550 ft. thick in Putnam county; mostly limestones.

5. *Siliceous group;* the "knobstones" of Kentucky. From 300 to 500 feet thick, including the Lithostrotion beds as its upper part.

4. *Black slate*, Devonian and Genesee, having a maximum thickness of about 60 feet.

3. *Upper Silurian* mostly or wholly, from 100 to 150 feet thick; mostly a series of limestones, some of which are impure, approaching fine sandstone or shale in character. The existence of these strata in the region of Glasgow is mainly *inferred* from the fact that they are seen in certain sections to the northeast and southwest of this point. They are, however, comparatively unimportant, and thin out southeastward and disappear.

2. *Nashville group*, Mr. Dana's Hudson period; blue fossiliferous limestones with some calcareous shales, 500 feet.

1. *Trenton limestones*, at the base of the section.

It may be remarked, in passing, that one of the most striking features of this section is the almost entire absence of the Upper Silurian and Devonian formations. In the Tennessee and Cumberland river portions, the Upper Silurian beds are wholly wanting, while the Devonian series is represented by nothing more than the thin Black Slate—a fact pointed out by me many years ago.

I have represented in the section the geological places of what we may call typical petroleum wells by the short heavy vertical lines. We will notice them in descending order.

1st. *In the Mountain Limestone.* The heavy line at *a* in the upper part of this formation indicates simply the geological level of the "Beaty oil well." Its geographical and topographical positions are very different. The well is located in Kentucky on the Big South Fork of Cumberland river, and near the Ten-

[1] The awkward term *subcarboniferous* ought to be dropped. Silurian rocks are subcarboniferous.

nessee line. The valley of the stream is, at the well, narrow, and is deeply set in the Cumberland table-land; it cuts through the Coal-measures and into the top part of the Mountain limestone, exposing about 50 feet of the latter. The Mountain limestone is therefore much depressed at this point. The well is sunk near the river, and is less than 200 feet deep. It was bored, about 1825, for salt water. At its greatest depth, a reservoir of oil was struck, from which so much petroleum flowed as to lead to the abandonment of the boring as a salt well. For several years after petroleum was gathered at this point for medicinal purposes. How much petroleum issued from this boring it is now impossible to tell. I give it simply as a good example of an oil reservoir actually tapped in the Mountain limestone.

2d. *In the Siliceous group.* There are several examples in this formation of reservoirs reached by boring. At *b* in the section the geological (not geographical) place of the "Porter well" in Allen county, Kentucky, is represented. This well is located on Bay's Fork of Big Barren, on a line between Scottsville and Bowling Green, and about seven miles from the former place and eighteen from the latter. This reservoir was tapped, some time in January of this year, at the moderate depth of 55 feet. It yielded for a number of days, by pumping, about 400 barrels of oil and strong brine per day, half of which was oil. At the time of my visit, Feb. 13th, it had produced altogether about 1000 barrels of petroleum, but was not then doing well.

In the southern part of Overton county, Tennessee, on Spring creek, is another example. Here a reservoir was struck which yielded heavy oil, but how much I am not informed.

3d. *In the Black Slate.* On Boyd's creek, near Glasgow, Kentucky, is a group of half a dozen wells or more. Their position is shown by the heavy vertical lines at *c*. One or two of these met with oil in the Black Slate.

4th. *In the Upper Silurian.* All of the Boyd's creek wells start in the Siliceous group, most of them pass through the Black Slate and terminate in this group. Taking all the wells, they vary in depth from 60 to 250 feet, averaging about 130 feet. So it was at least at the time of my visit. One of them was, and may be now, a flowing well, having yielded for many months nearly or quite 30 barrels of oil per day. One or two of these borings may reach the next group of limestones below. In fact practically, and possibly in reality, the rocks may be united with the Nashville group.

5th. *In the Nashville group.* This group has furnished the most and the largest reservoirs. The geological and topographical place of a number of borings, which have tapped oil reservoirs, on the Cumberland and Obey rivers, and on their tributaries, both in Kentucky and Tennessee, is shown by the heavy

short lines at *d, d.* The old "American oil well" near Burksville, originally bored for salt water, may be taken as an example. This, from top to bottom, is within the Nashville group. Its mouth is not far from 40 feet below the level of the Black Slate. At the depth of about 175 feet this boring tapped an oil reservoir, from which flowed out, at a minimum estimate, 50,000 barrels of oil. The recently bored Crocus creek well, which has yielded up to this time not far from 30,000 barrels, is another example. Other examples might be given, but these are sufficient. A great number of wells will be sunk in this formation during the present year.

6th. *In the Trenton limestones.* Some boring has been done in this series, but as yet no repositories of any note have been discovered, at least in Tennessee.

Nashville, Tenn., March 19th, 1866.

ART. XIX.—*Analyses of some minerals from the Emery mine of Chester, Mass.;* communicated by Dr. C. T. JACKSON. (From a letter to one of the Editors.)

1. *Andesine.*—The emery vein enlarges as it goes in, and from four feet has already widened to seven feet eight inches of solid emery of the best quality. The adit now is extended 260 feet. The portion of rock originally mistaken by me for granular quartzite, and called Indianite by Shepard, proves on analysis to be *Andesine*, although it is harder than stated in the books, scratching quartz crystal readily. It is associated with crystals of black tourmaline. It is very compact, fine granular in texture, with a conchoidal splintery fracture, and has G. = 2·586, H. = 7·5; the color slightly greenish white. I obtained for its composition,

	1.	2.
Silica,	62·00	60·00
Alumina,	24·40	25·00
Lime,	3·50	
Magnesia,	0·70	
Soda,	8·07	
Water,	1·00	
	99·67	

In No. 2 there was a trace of oxyd of iron not weighable.

2. *Analysis of Margarite*, by JOHN C. JACKSON.—The margarite of Chester has, G. = 3·03, H. = 3·5–4. The analysis afforded;

Silica,	29·84
Alumina,	53·84
Lime,	10·38
Magnesia,	0·24
Alkalies, soda chiefly,	2·46
Water,	1·32
Sesquioxyd of iron,	0·30
	98·38

3. *Diaspore.*—The first of the following analyses of diaspore was made by my son, John C. Jackson. I was in hopes he would have had time to repeat the work and determine the alumina directly,—an accident having damaged that part of his analysis so that he can give it only by difference. In my analysis of the same mineral the ingredients were all directly determined. The quantity analyzed at a time was 10 grains; two analyses were made. The diaspore is in prismatic crystals which contain microscopic crystals of Brookite. H. =7 nearly, scratching quartz distinctly but feebly. G. = 3·39. Analyses:

	1.	2.
Water,	14·75	14·8
Alumina,	[80·75]	83·0
Oxyds titanium and iron,	4·50	
Sesquioxyd of iron and oxyd titanium,		3·0
	100·00	100·8

The diaspore occurs in both the North and South Mountains, associated with emery and chloritoid. It exists both in bladed striated crystals, and in small prisms of considerable length, sometimes an inch or more long. Only the microscopic crystals present perfectly defined forms.

Chloritoid.—Ten grains of the chloritoid were selected for the analysis, as pure as possible, but it still contained microscopic particles of magnetic iron ore and perhaps of emery.

The results of my analyses are as follows. The second column contains these results as they would be if half the oxyd of iron is protoxyd:

	1.	2.
Water,	11·00	11·00
Silica,	22·50	22·50
Alumina,	23·50	23·50
Protoxyd of iron,		18·00
Sesquioxyd of iron,	41·50	20·25
Magnesia,	1·80	1·80
	100·30	97·05

If I can procure crystals free from any admixture I shall reanalyze it. It is plain that if the mineral is chlorite the magnesia is replaced by protoxyd of iron. It differs less from chloritoid but more from masonite, which by my analysis, published in my Report on the Geology of Rhode Island, contains 6 pr. ct. of oxyd of manganese and 32·20 of silica. The following is my analysis of masonite: (From analyses made in 1839 and published in 1840; Geol. of R. I., page 88, Prov., R. I., 1840. The analysis was repeated several times, and this is a mean of a number of carefully made analyses by myself on 25 and 50 grain lots.)

Water,	4·000
Silica	33·200
Alumina,	29·000
Magnesia,	0 240
Protoxyd of iron,	25·934
Oxyd of manganese,	6 000
	99·374

Boston, March, 1866.

ART. XX.—*On the detection of Iodine;* by M. CAREY LEA.

WHERE iodine exists in the form of hydriodic acid, or the iodid of a base, two methods are commonly employed to put it into a condition to be detected by the starch test. One of these is by the action of nitric acid, the other by chlorine or bromine water. The latter is the more delicate, but has the disadvantage that if the chlorine or bromine be added in excess, the reaction is missed.

It occurred to me while engaged in testing for iodine, that the facility with which that body is eliminated from its hydrogen and metallic combinations by *chromic acid* would make the latter substance a valuable means of bringing about the starch reaction, and a few experiments completely confirmed this view.

If, for example, we take an extremely dilute solution of iodid of potassium, such that the addition of nitric acid and starch produces no perceptible effect, the further addition of a single drop of very dilute solution of bichromate of potash will instantly bring about the characteristic reaction.

When chlorhydric acid is substituted for nitric, the effect of the bichromate is (as was to be expected) still more marked. The test has then the full delicacy at least of the chlorine test, with this great advantage, that an excess of the reagent does not prevent the reaction.

As to the delicacy of this test, the following observations were made.

With solutions of iodid of potassium up to one hundred thousandth (1 : 100,000) the precipitate was abundant, becoming less blue and more tawny as the dilution increased. Beyond this point the distinctness rapidly fell off. The indications were observable at one-four-hundred-thousandth. With a solution of one-eight-hundred-thousandth it was doubtful whether any effect was evident though still it was thought that a darkening was produced.

The experiment can be made in two ways, according to the result desired.

If it is wished to observe the effect of the chromic acid in increasing the delicacy of the indication, add the acid and starch to the very dilute solution of iodid, and then when the extreme dilution is such that no reaction appears, a drop of solution of bichromate instantly produces it.

But in employing the reagent in the search for iodine, add the starch to the liquid to be tested, stir it up, add a drop of dilute solution of bichromate, enough to communicate a pale yellow color, and finally add a few drops of chlorhydric acid. The test is then the production of the characteristic precipitate,

or in case of great dilution, approaching to a half-millionth, merely a tawny shade given to the solution.

It seems scarcely necessary to say that if a very great excess of acid is used, and too much bichromate, the starch may be made to reduce the bichromate. Even this, however, cannot deceive, for a bluish-green solution is thereby produced, whereas the indications of iodid are in the order of their strength: blue precipitate, tawny precipitate, tawny solution. Unless in the case of very exceptional dilution above spoken of, a well marked blue precipitate is always obtained.

The examination of the delicacy of the reaction with very dilute solutions was made at a temperature of 65° F. or thereabouts. This fact requires to be taken into account, as according to some experiments of Fresenius to be found in the Jahresbericht for 1857, the delicacy of the starch test increases as the temperature falls, so that at 0° C. a fainter trace can be rendered evident than at 12° C., and so on: the difference is asserted to be material. Fresenius's experiments were made with sulphuric acid and hyponitric acid, and the delicacy of the reaction obtained by him at corresponding temperatures seems to fall a little short of the above.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the preparation of Hydrofluoric Acid;* by W. P. Dexter.—Few chemists have at their disposal a distillatory apparatus of platinum, and the cryolite from which the purest hydrofluoric acid is prepared; and the shape commonly given to the dome of platinum retorts is such as to allow matter which may be projected upon it to flow down the neck into the receiver. The acid made from fluor spar in such a retort I have found to contain sulphate of lime. A simple remedy for this defect would be to fix in the dome a perforated disc, or ring, over the aperture of which another disc of less diameter, but larger than this aperture, is supported by three strips of platinum rivetted to the ring, both being made of silver platinum foil.

A dome of platinum attached to a leaden vessel seems to me a halfway measure, combining the disadvantages attending the use of both metals.

To those who are not in possession of an apparatus of platinum, I can recommend from experience the following comparatively inexpensive arrangement.

It consists of the ordinary leaden bore, (mine is 6″ high by 3½″ internal diameter,) made of a piece of lead pipe into which a bottom of lead is cast, and provided near the top with a small and short tube for the escape of the gas. The tube must incline slightly from the retort *up-*

ward, otherwise whatever is condensed or projected upon it will flow downward and the product be contaminated, at least, with lead. Into this tube a smaller one of platinum is luted, which is bent into the shape of a quarter of a circle so that the farther end points downward; this end is soldered with gold into the bottom of an inverted platinum crucible. An old one, perforated and cracked, such as is generally to be found in a laboratory, answers perfectly for the purpose.

The inverted crucible hanging like a bell at the end of the tube, when immersed in water contained in a vessel not very much exceeding it in diameter, offers a large surface for the absorption of the acid gas, while a retrocession of the liquid from absorption or change of temperature is impossible.

The cover to the retort may be cast in one piece with a shoulder, or be made of two discs of lead of the size of the inner and outer diameters of the bore, and held together by a ring of lead cast into them and serving as a handle. For a lute I spread a thin layer of gypsum on the surfaces in contact, and cover the joint on the outside with a paste of rye-meal.

2. *Skylight Polarization at Philadelphia;* by PLINY EARLE CHASE, A.M., S.P.A.S.[1]—Recent observations with a Savart polariscope having led me to results which, while generally confirmatory, differ in a few particulars from those published by Sir David Brewster, (Phil. Mag. [4], xxx, pp. 118, 166, sqq.), I place some of them on record, to facilitate a comparison with similar observations at other places.

(1.) In all the great circles which pass through the sun, the polarization of a clear sky is positive, except in the neighborhood of the solar and anti-solar points. If the polariscope is rotated from the positive maximum, the bands gradually diminish in brilliancy, vanishing at about 45°, and attaining a negative maximum at about 90°.

(2.) Within the primary lemniscates, of which the solar and anti-solar points are the respective centers, and the neutral points (actual or theoretical)[2] are the limits; the polarization of a clear sky is negative when the bands pass toward the sun's center, vanishing when the bands are inclined 45° to the solar radii, and attaining a positive maximum when the inclination reaches 90°.

(3.) Arago's and Babinet's neutral points can be seen as well before sunrise as after sunset, provided the atmospheric conditions are the same. Brewster gives the preference to the evening observations, but apparently for no other reason than that the sky is then usually clearer than in the morning, (op. cit., p. 118.)

(4.) I have repeatedly, and with little comparative difficulty, observed Brewster's neutral point. In the majority of cases, when the sun's altitude has been sufficient, I have been able to fix its position with nearly as much facility as that of Babinet's. (For the difficulties of Brewster and Babinet, see loc. cit., pp. 119, 166, 181.)

(5.) Within the solar primary lemniscate it is frequently difficult to make any ordinary observation of the polarized bands, on account of the dazzling intensity of the light. But when the direct rays of the sun

[1] From the Proceedings of the American Philosophical Society, Jan. 5, 1866.

[2] There is one *theoretical* neutral point below the anti-solar point. It is probably never above the horizon when there is light enough to determine its position.

have been shut off by a thin disc (placed with its edge towards the eye, so that the polarization will not be affected by reflection from the surface of the disc), I have often been able to mark the opposite polarizations and the position of the neutral points with perfect ease, even at mid-day.

(6.) In our climate it is by no means unusual to have days on which all the three neutral points can be observed, and their places determined. During the whole period of Brewster's observations at St. Andrews, he found but two such days, April 5th and 8th, 1842, (loc. cit., pp. 124, 163).

(7.) Quasi-neutral lines, dividing bands of opposite polarization, can be found in nearly all parts of the sky by rotating the polariscope 45° from the line of maximum positive or negative polarization. But a slight additional rotation will show that the neutralization is only apparent.

(8.) The position of a true neutral point can be determined by sweeping its neighborhood alternately with the vertical and with the horizontal bands, and marking the intersection of the lines of vanishing polarization.

(9.) In consequence of the arrangement of the lines of equal polarization, when the sky is swept with the polariscope for a few degrees on each side of a neutral point, the line which separates the oppositely polarized bands forms curves with a convexity determined by the position of the sun or of the anti-solar point.[9]

(10.) Some of my observations have indicated an apparent correlation between these curves and the magnetic dip and terrestrial latitude. I have not been able to satisfy myself whether the correspondence was merely accidental, or whether it indicated another point of analogy between the laws of light and of magnetism.

(11.) The varying effects of haze and cloud, appear, on the whole, to sustain Brewster's theory, that the neutral point is produced "by the opposite action of light polarized by reflexion and refraction." (See pp. 123, 169, 176, 178, 180.)

(12.) In one instance, soon after sunset, the reflection from scattered clouds in the neighborhood of the anti-solar point was such as to totally eclipse Arago's neutral point, the polarization being positive over the entire arch, from Babinet's neutral point to the eastern horizon.

3. *Comparative visibtlity of Arago's, Babinet's, and Brewster's Neutral Points;*[1] by PLINY EARLE CHASE, M.A., S.P.A.S.—In my communication of January 5th, I stated that when Brewster's neutral point is above the horizon, I had frequently determined its position with great ease. My experience was so different from those of Brewster and Babinet, that I commenced on the 6th of March a series of comparative observations upon the three neutral points. The month which has just ended appears to warrant the following conclusions for stations in Philadelphia and its vicinity. The 1st, 2d, and 6th seem to be confirmed by observations elsewhere, while the 3d, 4th, and 5th, which are, perhaps, dependent partly upon local atmospheric peculiarities, have never, so far as I am aware, hitherto been noticed.

[9] I am not sure whether this is the "singular effect" thus described by Brewster (loc. cit., p. 124); "In conveying the bands vertically round, the neutral line, in place of crossing them at a right angle, was the arc of a circle, to which one of the bands was a tangent." (See, also, pp. 121, 167.)

[1] From the Proceedings of the American Philosophical Society, April 6, 1866.

(1.) Arago's neutral point often assumes a distinctness which is never exhibited by either of the others, merely because the polarized bands in the vicinity of the sun are obscured by the dazzling brilliancy of its rays.

(2.) For the same reason, Babinet's neutral point is often better defined, in the morning and evening, than Brewster's during the middle of the day.

(3.) But when Brewster's and Babinet's neutral points are both above the horizon, if the sky is clear, the former is generally *more easily* posited than the latter. This is especially the case at midday.

(4.) On every clear day, and on a large portion of the days which are partially obscured by clouds, the position of each of the neutral points can be determined. Brewster records but two days during five years' observations (Phil. Mag. [4] 30, 124), upon which he saw all the points.

(5.) Arago's neutral point often rises before Brewster's sets. Under favorable atmospheric conditions the three points are, therefore, sometimes simultaneously visible.

(6.) Halos and clouds are frequently discernible through the polariscope, which are invisible to the naked eye.

The following abstract embodies some of the results of the month's observations:

Satisfactory observations were made on	25 days.
All the neutral points were seen on	17 "
There were no satisfactory observations on	6 "
" " 39 observations of Arago's neutral point on	23 "
" " 93 " " Babinet's " "	22 "
" " 59 " " Brewster's " "	20 "
Arago's neutral point was remarkably distinct on	4 "
Babinet's " " "	10 "
Brewster's " " "	11 "
Arago's was the only one observed on	2 "
Babinet's " " "	1 day.
Babinet's and Brewster's the only ones seen on	1 "
Arago's and Babinet's " "	2 days.

The three points were simultaneously visible on April 5th, from $4^h\ 32'$ to $4^h\ 42'$ P. M.

Brewster's neutral point was perceptibly more than Babinet's at fifteen observations, and less distinct at two observations.

I subjoin a few of my notes, which refer to points of special interest: March 8th, $5^h\ 45'$, P. M. Near the proper position for Arago's neutral point, the positive and negative polarities coalesce upon clouds, with no intervening space or neutral line.

March 9th, $6^h\ 25'$, A. M. Hazy and polarization fluctuating. $10^h\ 40'$, A. M. The polariscope showed a brilliant halo around the sun, which I had not before noticed, but which was afterwards barely visible to the naked eye. $12^h\ 10'$, P. M. Haze continues. Negative polarity remarkably distinct over the face of the sun, and for several degrees North and South.

March 11th, $3^h\ 50'$, P. M. Sky covered with thin clouds. A neutral point in the East, 42° above the horizon, and *more than* 70° *from the anti-solar point*, with reversed polarization, or positive below, and nega-

tive above. $5^h\ 25'$. A similar point still observable, but about 5° nearer the horizon.

March 12th, $6^h\ 30'$, A.M. Cloudy. Polarization positive from East and West horizon, nearly to Zenith. A similar observation was made March 21st, at 6^h P.M.

March 17th, $9^h\ 15'$ and $10^h\ 40'$ A.M.,[3] and March 18, $10^h\ 30'$, A.M.[3] Very clear. Sun so bright that I was unable to detect the negative polarity between Babinet's neutral point and Brewster's, even by screening the eye from the direct light of the sun.

March 19th, $11^h\ 5'$, A.M.[4] Halo, visible only through the polariscope. 1^h P.M. Snowing.

March 20th, $5^h\ 25'$, P.M. Cloudy. Polarization in horizon everywhere positive.

March 24th to 28th, inclusive. On each of these five successive days Brewster's neutral point was remarkably distinct and beautiful.

April 3d, $5^h\ 40'$ P.M. Cloudy in West, and polarization positive from zenith to horizon.

Strong reflection sometimes changes the character of a comparatively weak polarization, from positive to negative, or *vice versâ*. A fainter reflection, by showing whether the bands are interrupted or continuous, often aids in determining the character of the polarization.

The increased refraction of a piece of glass, interposed between the polariscope and the sky, will frequently show a neutral point which is otherwise invisible.

The normal polarity is often reversed by a stratum of clouds of uniform thickness, especially within the solar primary lemniscate.

II. MINERALOGY AND GEOLOGY.

1. *On the age of the gold-bearing rocks of the Pacific Coast;* by Prof. WM. H. BREWER. (Communicated for this Journal).—In the preceding number of this Journal, in a *résumé* of Whitney's "Geology of California," I noticed in some detail (pp. 361–364,) the principal data from which the secondary age of the auriferous rocks of the Pacific Coast had been deduced, with the dates of the more important discoveries, and of their first publication. These included a reference to the more important fossils that had come under the observation of the members of the Geological Survey up to the time of Prof. Whitney's first publication, together with some additional facts, confirming the conclusions that had been discovered later.

Since that article was printed, a paper bearing about the same date has been received, entitled,

"Annotated Catalogue of the Principal Mineral Species hitherto recognized in California and the adjoining States and Territories; being a Report to the California State Board of Agriculture, by WM. P. BLAKE, Geologist of the California State Board of Agriculture, and Professor of Mineralogy, Geology, and Mining, in the Department of Science of the College of California. Sacramento, March, 1866.

[3] On steamboat in Raritan Bay.
[4] In New York.
[3] At Eagleswood, near Perth Amboy.

In addition to the Catalogue of Minerals it contains about four pages of, "Notes on the Geographical Distribution and Geology of the Precious Metals" "on the Pacific slope."

These "Notes" contain statements apparently so entirely at variance with the facts I detailed in the *résumé* mentioned, that, unless answered, they are not only calculated to mislead those who are interested in the history of geological discovery in California, but also to call in question the authenticity of some of those facts; as well as the statements relating to them in the various publications of the California geological survey. The official character of this document gives the remarkable statements and claims it puts forth their principal weight, and demands that they be carefully examined, particularly as regards those differences which exist between these statements on the one side, and those published in Prof. Whitney's Reports and papers on the other. This is especially important as it relates to the question, *who first demonstrated and first published the Secondary age of the auriferous rocks of California.* Prof. Blake says:

"After years of laborious search for fossils by which the age of the gold-bearing rocks might be determined, I had the pleasure, early in 1863, to obtain a specimen containing *Ammonites*, from a locality on the American River, preserved in the cabinet of Mr. Spear. This fossil was of extreme importance, being indicative of the Secondary age of the gold-bearing slates, and was therefore photographed, and copies of it sent to the Smithsonian Institution at Washington, for description. It was subsequently noticed in the Proceedings of the California Academy of Natural Sciences, Sept. 1864." (Page 28 of pamphlet.)

We might infer from this, (1,) that the fossil spoken of was found *in place*, (for similar fossils found not in place had been known several years earlier); (2,) that it was sufficiently well preserved to be determined, and even from a photograph; and (3,) that its secondary age was published in Sept. 1864. I find on referring to his original paper, (Proc. Acad. Nat. Sci., iii, p. 167, which was not published until *December*, 1864,) the following additional information: "It is not certain whether the specimen was taken from the slates in place, or broken from a loose mass." "It is not possible to determine from the specimen whether these fossils are new or not, *or even whether they are ammonites or ceratites.*" This announcement was made a year (and it was not published until three months later) after the Geological Survey had taken nearly twenty recognizable species of Jurassic and Triassic fossils from the auriferous slates, and also later than the publication of Prof. Whitney's announcement in this Journal of the Secondary age of the formation. I leave out of consideration the Carboniferous fossils found in limestones enclosed in the true slates, near Pence Ranch, in 1862, and the other discoveries of fossils before Sept. 1864, which are noticed in the Report on the Geology of California.

He observes again:

"The same year, when at Bear Valley, Mariposa county, upon the chief gold-bearing rocks of California, I identified a group of Secondary fossils from the slates contiguous to the Pine Tree Vein, and noticed them at a meeting of the California Academy, Oct. 3, 1864, announcing the Jurassic or Cretaceous age of these slates. The best characterized fossil was a *Plagiostoma*," &c. (Ib.)

These fossils were *not* found in 1863, as the language implies, but late in Sept. 1864. On referring to his original paper in the Proceedings of the Academy, (iii, p. 170), I find that he "identified" the fossils by referring them all to wrong genera, (as determined by Mr. Meek).

Again he states:

"The attention of the Geological Survey having been directed to this locality by my announcement and exhibition of fossils in San Francisco," &c. (Ib.)

The attention of Mr. Gabb and myself was directed to those particular species by the announcement; but Mr. King had already procured and forwarded to Prof. Whiting, for description by Mr. Meek, similar specimens from the same locality before Prof. Blake had seen or heard of a fossil being found there. I had not been advised of Mr. King's action in the matter, nor had Mr. Gabb, who afterwards visited the locality and obtained more specimens.

He remarks further:

"It appears also, from the same source, (Whitney's Geology of California), that Mr. King, a gentleman connected with the Survey, had obtained *Belemnites* from the Mariposa rocks in 1864," &c. (Ib.)

Prof. Blake neglects to add that the same source informs him that these Belemnites were found *in place* very near to Pine Tree vein, and *eight months before* the fossils mentioned in the preceding paragraph had been found.

Again:

"The Silurian age of the gold rocks of California has not always been assumed. It has been repeatedly questioned. In the preface to the writer's 'Report of a Geological Reconnoisance in California' it is stated that a considerable part of the gold-bearing slates of California are probably Carboniferous." (p. 29.)

I find on referring to that preface by him that the next sentence to the one he cites is as follows: "It is also probable that a great part of the rock formations of the gold region will ultimately be found to be Devonian or Silurian," &c., and in the later pages of the same work he paves the way for priority of discovery, should they actually prove to be Silurian, by stating that the conclusions arrived at by Sir R. I. Murchison were confirmed by his (Prof. Blake's) observations in California.

Again:

"The opinion of the comparatively modern age of the gold rocks has been steadily gaining strength for years past, and has been the subject of discussion in the daily journals."

As he does not cite his authorities in this case, I cannot positively deny that such *surmises* may have been printed, but I never saw them until *after* Sept. 1864, since which date certain writers have recollected that they had arrived at these conclusions, and are now putting forth claims for their "discoveries."

I maintain that Professor Whitney's article in the American Journal of Science, Sept. 1864, is *the first published statement of the fact*, that "the sedimentary portion of the great metalliferous belt of the Pacific coast of North America is chiefly made up of rocks of Jurassic and Triassic age, with a comparatively small development of Carboniferous limestone," (Am. Jour. Sci., xxxviii, p. 261). This was widely circulated, and was even reprinted in Europe, before Prof. Blake's "announcement,"

and some months before said announcement was printed. (See London Mining and Smelting Magazine, Oct. 1864, pp. 215–217).

And, furthermore, the conclusions were reiterated in the preface to the Paleontology (vol. i, p. 18,) which was issued in Dec. 1864, the same month with Prof. Blake's paper, and this in turn received notice in this Journal for Jan. 1865, p. 99. In this volume were described over 50 species of fossils of the age under consideration, more than half of which had been found in California in the rocks associated with gold. Many of the plates and descriptions of these fossils had been prepared more than a year before this, or in 1863.

Prof. Blake adds:

"I regret to observe that in this publication (Whitney's Geology of California), as well as Mr. Gabb's notice of the fossils, no mention is made of my previous announcement, and that my part in the discovery and publication of the Secondary age of the Mariposa gold rocks is studiously and wholly ignored." (Foot-note to p. 28.)

While the language quoted only strictly claims a part in the "discovery and publication of the Secondary age of the *Mariposa* gold rocks," yet any person not acquainted with the facts, and not examining the dates of the original discoveries and publications, would draw the inference from the connection in which the statement stands, that Prof. Blake had been the first to discover and announce the age of these rocks, (if not of the gold series of the State as a whole). But I have already shown that, even as applied to the Mariposa rocks, the claim is unfounded. Mr. King antedated him eight months in the discovery of fossils, and Prof. Whiting three months in publishing the conclusions.

Nor could Prof. Blake have been ignorant of this, for he had all the printed data in the Reports he cites.

The article under review being an official Report published by the State Board of Agriculture in the Transactions of the State Agricultural Society, as well as in pamphlet form, is intended to reach the more intelligent portion of the people of that State, to diffuse reliable information among them, to influence their future policy in official surveys, as well as "to help to arouse an interest in the science of mineralogy among our people." The natural inference drawn from the language and bearing of this part of the document, is, that Prof. Blake, the Geologist of the Board of Agriculture, had made the first discovery and announcement of the true age of the great metalliferous belt of the State, and that the State Geological Survey had robbed him of the honor and ignored his discoveries. No one would suppose after reading it that his "years of laborious search for fossils" had been so poorly rewarded, or that his "part in the discovery and publication of the age of the gold rocks" had occurred so long after the discovery and publication of the fact by the Geological Survey.

For the information of those interested in the question, I will here state that I was in California during the period of the discoveries under consideration, and collected a part of the fossils in the possession of the State Geological Survey, and was acquainted with the localities and dates. I was present at the meeting of the California Academy, Oct. 3d, 1864, when Prof. Blake exhibited his Mariposa fossils and made his so-

called "announcement." He prefaced his paper by stating that after years of search for fossils in the gold rocks, by means of which their age might be determined, those which he exhibited were the first he had been able to obtain, and that his attention had been called to these and their locality by Miss Errington. In the verbal discussion that followed the presentation of his paper, I stated the main conclusions arrived at by the Survey, on the subject of the age of the gold rocks. I had already received Prof. Whitney's paper, (which had been published a month earlier), and stated some facts not there detailed in regard to the localities of fossils, and that the Survey had "found fossils in the rocks associated with gold along a line nearly 300 miles in length, extending from Pitt River to the Mariposa Estate," &c. (For synopsis of these remarks, see Proc. Cal. Acad. Nat. Sci., iii, p. 198). I described minutely the Genesee Valley localities for Jurassic, Triassic, and Carboniferous fossils, so that Prof. Blake might find them, as he proposed visiting that region soon. Yet I find in his pamphlet, (p. 28,) the statement, "Fossils of Secondary age from Genesee Valley, in the northern part of the State, *were common in collections in* 1864. (!)

New Haven, June 1st, 1866.

2. *A Catalogue of the Paleozoic Fossils of North America, Part I, Echinodermata;* by B. F. SHUMARD, M.D. 73 pp. 8vo. (From the Transactions of the Academy of Sciences of St. Louis, vol. ii, 1866).—The first signature of Part I, of this Catalogue, to the 13th page inclusive, was issued in the form of extrás, in July or August, 1865, and noticed on page 124 of the January number of this Journal for 1866. The succeeding signatures of this part, bear the dates of August and October, 1865, and February, 1866, at which dates extra copies were distributed by the author. Parts 2d, 3d, &c., now in course of preparation, or in the press, will consist of lists of the Plants, *Polyzoa*, *Brachiopoda*, and other groups of North American Paleozoic fossils.

Part I, of this catalogue, now published, and here noticed, is a complete list of the known North American Paleozoic *Echinodermata*. It is not an attempt at a classification of these ancient *Echinodermata*, by arranging them into families or larger groups, in accordance with their zoological affinities, but a simple alphabetical list of species and genera, with full references to the works where they were described or noticed; and as such, it will be a valuable aid to those who may wish to study this class of fossils, since it forms a complete index to the entire literature of the subject. It also gives the geological position of each species, with something of the synonymy, and contains numerous foot-notes of remarks, including descriptions of some of Dr. Troost's previously unpublished genera,[1] and a few new species. At the end of the list, there are likewise tables showing the geological range of the different genera.[2] The whole number of species included is 750, of which 97 are from the

[1] It is probable that *Cupellæcrinus* Troost, described on p. 361, is not distinct from *Marsupiocrinites* Phillips, (see Murchison's Siluria, p. 219), unless we admit the presence or absence of a proboscis as a distinction.

[2] As it is a pretty well established fact that there are three Archimedes limestones in the Sub-carboniferous series of the Western States, it would have been better if the author had recognized these as distinct rocks, in giving the geological range of genera and species.

Lower Silurian, 86 from the Upper Silurian, 115 from the Devonian, and 452 from the Carboniferous rocks.

In regard to synonymy, in a group like this, including so many closely allied species of which only descriptions have been published, there will of course, be differences of opinion; and beyond the instances where direct comparisons of authentic examples of the allied forms have been made (in cases where no figures have been published), any views on the subject can only be regarded as mere *opinions*, that may be right or may be wrong. Some of the supposed synonyms are believed by the writer of this notice to be distinct species; while he has no doubts whatever in regard to the distinctness of other forms, between which comparisons are suggested. These suggestions, however, will be useful even when the species alluded to are distinct, as hints to those who may have the means to make comparisons, and wish to do so, with the view of studying the relations of allied species.

Although we take great pleasure in bearing witness to the general accuracy and completeness of this valuable catalogue, there are a few points of nomenclature, in which we cannot agree with its author. For instance, in retaining *Elœacrinus* Roemer, 1851, instead of *Nucleocrinus* Conrad, 1843. The reason assigned for retaining Roemer's name is, that Conrad (perhaps on account of the imperfection of his specimen) did not define his genus correctly. As he gave a figure of his typical species, however, *E. elegans*, that need not be confounded with other types, surely his name should stand. If we were to throw aside all the names not accompanied by correct diagnoses, great confusion would result, since many of the descriptions published by Linnæus, Müller, Link, and various other early investigators, as well as by many later ones, would apply equally well to almost any other genus of the entire family; while not unfrequently the few characters given by them were not all strictly applicable to the particular type named. Where they cited known species, however, or referred to figures, that leave no doubts in regard to the particular genera they had in view, their names have been adopted notwithstanding the defects of their diagnoses. Where an author has given us the means of knowing, beyond a reasonable doubt, what group he proposed to name, either by his diagnoses, his figures, or citations, or all taken together, his name should stand; as in the case of *Bellerophon* Montfort, which no one has ever proposed to reject, because its author described it as a chambered shell,—simply from the fact that his figure shows at a glance what genus he had in view.

Again, we cannot agree with the author of the catalogue in citing *Gilbertsocrinus* Phillips, as a synonym of *Rhodocrinus* Miller, (although he has high authority for so doing,) and placing *Goniasteroidocrinus* as a subgenus under *Rhodocrinus*. There can be little doubt in regard to *Gilbertsocrinus* and *Goniasteroidocrinus* being congeneric, though they may be subgenerically distinct.[3] That they are both distinct generically from *Rhodocrinus*, however, it is believed will be at once apparent to any one who may see a specimen of *Goniasteroidocrinus* or *Gilbertsocrinus*, with its arms and pseudo-brachial appendages unbroken. Indeed, Mr. Billings hinted at the probability that *Gilbertsocrinus* would be found to

[3] See note on this subject in Proc. Phil. Acad. Nat. Sci., Aug., 1865, p. 166.

be a distinct genus, merely from inspecting Phillips's figures of imperfect specimens. The only question, in the opinion of the writer, respecting the name *Gilbertsocrinus*, is whether it may not have to give way to the older name *Ollacrinus* Cumberland, 1826. If de Koninck, Pictet and others are right in the opinion that *Ollacrinus* was founded upon one of the same types as *Gilbertsocrinus* Phillips, 1836, then Cumberland's name must take precedence, and our American species described under the names *Trematocrinus* and *Goniasteroidocrinus* will have to take the names *Ollacrinus tuberosus*, *O. fiscellus*, *O. typus*, *O. papillatus*, *O. robustus*, *O. tuberculosus*, *O. reticulatus*, &c.

At the end of the catalogue under review the author states in a note, the *Cœliocrinus* Meek & Worthen, recently proposed for a section of *Actinocrinus*, would have to be changed, because *Cœliocrinus* had been previously applied by Dr. White to another type. This, however, is an error, since the names are not identical, *Cœlocrinus* being derived from κοῖλος, *hollow*, and κρῖνον, *a lily*, in allusion to the concave base of the type; while *Cœliocrinus* is from κοιλία, *the belly*, and κρῖνον, *a lily*, in allusion to the ventricose proboscis of the typical species. Hence, these names are not only different in meaning, but they are also quite as much so in sound, and to the eye, as many others now in use in various departments of natural history; such for instance as *Bulla*, *Bullia* and *Bullæa*, *Trigona* and *Trigonia*, *Astartella* and *Astartila*, as well as various others that might be mentioned in conchology alone. As a general rule, however, it is, of course, better to select names less nearly alike; but it is sometimes scarcely possible to do so if we use a descriptive name at all.

Geologists and paleontologists will certainly feel under many obligations to Dr. Shumard for the preparation of these useful lists, which will so materially facilitate their investigations; and if all cannot agree with him in every particular, it will, we think, be generally conceded that he has performed the task with skill and impartiality. M.

3. *On the deposit of Rock Salt at New Iberia, Louisiana;* by Prof. RICHARD OWEN.—Prof. Owen stated that, having heard various accounts of the rock-salt in Louisiana, he had naturally felt very anxious to examine the deposit personally. At New Iberia, La., in November last, he resigned his commission as Colonel of the 60th Indiana Regiment to accept the chair of Natural Science in the Indiana State University. Learning that the distance from New Iberia to the salt works was not great, he delayed his departure for three days for an opportunity to visit them. This was afforded him through the courtesy of Major-General Franklin; and, although the day proved very rainy, he was enabled to make a satisfactory examination of the entire locality, under the polite guidance of Mr. Henshaw.

Fifty years before this period, Mr. Marsh the father-in-law of Mr. Henshaw, had sunk a well on his plantation, "La Petite Ance," distant in a southwest direction from New Iberia about twelve miles, and only two or three miles from the Gulf of Mexico. The water from this well proving a good brine, Mr. Marsh boiled it down and made considerable quantities of salt. When, however, the demand for salt became greater, at the breaking out of the war, Mr. Marsh's son requested permission to

sink other wells, hoping to obtain a stronger brine. After digging fifteen feet, one of the negroes employed struck a hard substance with his pick-axe, and was desired by the owner to go on and throw out some of the supposed rock. On washing off the excavated mass, it proved to be pure, hard rock-salt.

The area found, at which, by probing to the depth of from 15 to 18 ft., rock-salt was struck, indicates that the deposit underlies several square acres, perhaps four to six. The materials passed through, to reach it, are chiefly bluish clay, sand and gravel, with some lumps of micaceous sandstone. At the above depth, within that area, under every place at which they have bored or dug down, they reached the solid rock-salt. Through this solid stratum they bored twenty-six feet, and still found the salt deposit.

In getting it out for sale, it was found necessary to blast in the usual manner for obtaining building rock; and, even after purchasing moderate-sized lumps, the consumer has considerable difficulty in reducing them to a size fit for use. This compactness seems also to protect the salt from deliquescence, and even to enable it for a long period to resist solution when immersed in water. He was assured that large lumps, packed in barrels, had been sunk in creeks and ponds for concealment, and taken up weeks afterwards scarcely at all diminished in bulk.

The accumulation of 15 to 18 feet of clay, sand, and gravel on the deposit had evidently been the result of comparatively recent washings from the adjoining hills; and the deposit has, no doubt, been worked by the aborigines, as, at more than one place, on reaching the rock-salt, Indian relics were found. He saw, at Mr. Henshaw's, a basket, obtained from the surface of the rock-salt, 15 feet below the surface of the soil, made of split cane; and was informed that they also found pieces of charcoal, apparently the remnants of fires or torches. A rope of bark, wooden hooks, stone axes and pottery were likewise obtained.

Before he visited the locality, the citizens of New Iberia told him the formation was volcanic, and that several similar, crater-shaped eminences existed along the Gulf shore. Upon close examination, however, he not only found no volcanic or other igneous rock whatever, but saw at several natural washes, and at cuts in the semi-circular hill, or ridge, distinct depositions of successive layers of sand and gravel; the latter entirely rounded by attrition, and chiefly quartzose. That thrown out at the old salt-openings was of the same character.

The highest point of the ridge is 160 feet above the water in the Gulf at low tide. The sea, occasionally, from the combined influence of spring tides and a wind blowing strongly from the south, rises in this region to a considerable height, inundating the low lands and leaving salt marshes; which circumstance almost renders the plantation an island, although it is strictly peninsular. Formerly they reached it through canals in the marsh by boats; but when salt became valuable, a causeway, or raised road of dirt from the marsh, covered with plank, was constructed; and wagons came many miles to carry it off, at a cent and a half per pound, delivered at the mouth of the excavation.

After an inspection of some hours, made, as remarked, rather unfavorably on account of rain, but still sufficiently in detail to be certain of

the facts, and, after having obtained and closely inspected numerous specimens of the rock-salt, gravel, lumps of sandstone, and one very fine crystal, over two inches cube and nearly transparent, all of which are now in the Indiana State University, he felt assured that the whole phenomena must be referred to aqueous action.

In all probability, the semicircular deposit of sand and gravel, thrown to the height of 160 feet and conforming generally to the contour of the sea coast, resulted from the combined action of the winds and the waves of the ocean. In a similar manner, sand-ridges of nearly the same height have formed on the south shore of Lake Michigan, conforming to its coast outline; the latest and most northerly being close to the water's edge, and having formed since the settlement of the country by the white man.

As the result of similar causes, he conceived that these sea-beach ridges, on the Gulf, after being thrown up some height, permitted the high waters to flow round and into the basin-shaped depression left on the landward side, but impeded the return of the waters thus arrested.

The heat of the sun would be sufficient to evaporate the water, leaving the saline deposit; and thus, through a succession of ages, a repetition of like causes and results might readily give rise to the deposit just described. We have vegetable deposits which formed coal at various geological periods, although chiefly in the true Carboniferous era; and so we may also have saline deposits, greatest, as in Europe, during the New Red sandstone or Saliferous Period, yet taking place also during the Quaternary Epoch.

When, however, these ridges on the Gulf coast became high enough to have their materials frequently washed down by rains, the interior basin would readily fill up, and the detritus gradually cover any articles left by the aborigines. The salt and exclusion from air are sufficient to account for the preservation of the relics from decay for a long period.

The great inundation which, a few years since, destroyed so many families, who had visited Lost Island as a watering-place, was of the character above alluded to, and took place only about fifteen miles from the salt locality just described.

Whether or not the explanations here offered of the interesting phenomena exhibited at La Petite Ance is correct or not, the facts are important; and the evidences remain there to be examined at any time by those interested. The locality can be reached by railroad travel of 80 miles from New Orleans to Brashear City; thence, crossing Berwick Bay, the traveller, taking horseback or other conveyance for about 40 miles, reaches New Iberia; thence it is ten miles more to the causeway of the plantation, and two to the salt-boring; which is, as stated, on a peninsula, with Marsh Island on the south, and Vermillion Bay on the west.

The property has been sold by Mr. Marsh, and is now owned (he believed) by Mr. Avery.

It may not be irrelevant to remark, as a proof that, at no very distant period, saline inundations extended more than twenty miles inland from the present coast line of the Gulf, or at least impregnated the waters of the Bayous, that he had traced the Gnathodon (a genus of bivalves found abundantly around New Orleans, and peculiar to brackish water) along

our route of march, by the Tèche, at least five miles north of Franklin, Louisiana.

He would also add, that although borings have been made to even more than 15 or 18 feet at other parts of the Gulf coast, which seemed similar in character, as yet no other considerable deposits had been found; notwithstanding that, in some places, as he understood, salt had been made from the brine springs or wells.—*Trans. Acad. Sci., St. Louis*, ii, 250.

4. *Fossil Spider from the Coal formation;* by Dr. F. Rœmer, (Jahrb. Min. of Leonhard & Geinitz, 1866, p. 136).—Dr. Rœmer has here described and figured a very perfect specimen of a spider from the Coal formation of Upper Silesia. It is called the *Protalycosa anthracophila*, a name that implies a near relation in general habit to the modern Lycosa. The body is about an inch long. Appended to this paper is a notice of a specimen of *Arthropleura armata* Jordan, from the Carboniferous beds of Zwickau, by Dr. Geinitz. The specimen is sufficient to show that the animal was a Crustacean; it is evidently part of the carapax, and probably of a Decapod.

5. *Observations on the Cretaceous strata of Texas;* by B. F. Shumard, M.D., State Geologist. 9 pp. 8vo. From the Transactions of the Acad. Sci. at St. Louis.—The paper gives an important section of the strata with descriptions and a list of fossils. The Lower Cretaceous—arenaceous and marly—is 230 feet thick, and the upper, which is the calcareous division, is 800 to 1000 feet thick in the eastern portion of the State, and of much greater thickness in the west.

6. *Report of the Chief Commissioner of Mines for the Province of Nova Scotia, for the year* 1865; by S. P. Hamilton, Provincial Secretary. 32 pp. 8vo. 1866. Halifax, N. S.—This Report treats mainly of matters of economical interest. We learn from it that the quantity of gold from the mines, on which royalty was paid, was, for the year ending 30th Sept., 1864, 18,744 oz., 5 dwt., 12 gr.; and for the following year, 24,867 oz., 5 dwt., 22 gr. Also, that the number of collieries in operation in Nova Scotia is thirty; and that the total quantity of "Round and Slack Coal" sold from the mines during the year ending Sept. 30, 1865, was 652,854 tons.

7. *Geological Survey of Nova Scotia:* Prof. How's *Report on certain minerals found by Dr. Honeymann.* 4 pp. 4to.—The minerals are ores of copper, lead and iron, barytes, limestone and "pencil stone."

8. *Sulla Geologia dell' Italia centrale:* estratto di alcune lezioni orali date nel maggio, 1864, dal Cav. Igino Cocchi, raccolte e publicate per cura di C. Puini e di A. Mariani. 100 pp. 8vo., with 2 plates. Firenze, 1864.—The author discusses with new and interesting views the nature and origin of the later formations and the features of Central Italy.

9. *Petroleum on the Alleghany River at Brady's Bend.*—Prof. J. P. Lesley has an article on the discovery of oil at Brady's Bend, and on the geology of the region, in the Proceedings of the American Philosophical Society, x, 266, 1866.

10. *Orographic Geology, or the Origin and Structure of Mountains: A Review;* by George L. Vose, Civil Engineer. 136 pp. 8vo. Boston, 1866.—The author of this work has here presented a general

review of the theories that have been brought forward to account for the disturbances, flexures or displacements, metamorphism and elevations, that have taken place in the earth's crust. These theories, and the objections to them, appear to be fairly presented, with a citation of a large number of authorities; and the work may be profitably read by all who would study this obscure department of geology. The author very judiciously does not add to the number of hypotheses, yet briefly draws some conclusions from the survey. Upon these conclusions we may remark in a future number.

11. *Dentex Münsteri, specie di Pesce i cui resti fossili, trovati nelle Argille Subapennine del Volterrano dal Dott. G. Amidei*, sono descritti ed illustrati dal Prof. C. GIUSEPPE MENEGHINI. 26 pp. 4to, with a plate. Pisa, 1864. (Nistri.)—Prof. Meneghini, besides describing a fossil fish of the genus Dentex, shows that two bones described by C. di Münster as portions of what he calls *Capitodus subtruncatus* and *C. interruptus*, belong to one and the same species, and that this species is identical with his own. He therefore gives the species the name *Dentex Münsteri.*

12. *G. F. Matthew on the Azoic and Paleozoic rocks of Southern New Brunswick*, with a map.—Mr. Matthew's valuable paper is published in the Proceedings of the Geol. Soc. London for May, 1865 (p. 422). The following are some of his conclusions: that the geological formations of Acadia include rocks of all ages, from the Huronian to the Carboniferous inclusive, with only one important hiatus in the absence of rocks of the Trenton period; that the Primordial shales are conformable to the Huronian beds; that there were disturbances at the close of the Lower Silurian as well in Acadia as in New England; others between the Upper Silurian and Lower Devonian; but far the greatest or most marked between the Devonian and the Lower Carboniferous; and perhaps a fourth between two sections of the Carboniferous system. The valuable map accompanying the paper is stated to have been prepared by Prof. L. W. Bailey and Mr. Matthew.

13. *Meteorites.*—A very important memoir on meteorites has recently been presented by Mr. Daubrée to the Academy of Sciences of Paris, and has appeared in volume lxii of the Comptes Rendus. It takes up the nature of meteorites in general, and discusses in a brief manner the following subjects: The products of the fusion of meteorites; their analogies to terrestrial rocks, and the imitation of them by treatment of these rocks; the transformation of serpentine into chrysolite, or into lherzolite, and an attempt to imitate meteorites by means of this rock; importance of magnesian rocks of the chrysolite kind both in the case of the earth and of the planetary system; new experiments illustrating the original formation of the masses from which meteorites have proceeded; application of the subject to the earth-origin of chrysolite as a universal scoria. In the fusion of serpentine from different localities (Snarum in Norway, Zœblitz in Saxony, Baldissero in Piedmont, etc.) Daubrée obtained, as the usual product, a mixture of chrysolite (silicate of iron and magnesite) and enstatite (bisilicate of magnesia). The enstatite occurs sometimes in groups of needles distributed through the crystalline chrysolite. The rock called lherzolite, from the vicinity of Lake Lherz, in France, is essentially a compound of these two minerals, chrysolite and

enstatite. From his results he concludes that serpentine has been a common source of chrysolite. The memoir merits close study.

14. *Annotated Catalogue of the principal Mineral species hitherto recognized in California, and the adjoining states and territories*, being a Report to the California State Board of Agriculture; by Wm. P. Blake, Geologist of the Calif. State Board of Agriculture and Prof. of Min., Geol. and Mining in the College of California. 32 pp. 8vo. March, 1866. Sacramento.—Prof. Blake has done a good service to mineralogy in this catalogue of California and other west-American mineral localities. The pamphlet contains, besides a mention of the localities, notices of the associations and characters of some of the species, and a list of private and public cabinets in California. It closes with a chapter of four pages containing Notes on the Geographical distribution and Geology of the Precious Metals and Valuable Minerals of the Pacific Slope of the United States, some points in which Prof. Brewer has criticized at page 114.

15. *Die Minerale der Schweiz*, von Dr. Adolf Kenngott. 460 pp., 16mo, with 78 woodcuts. Leipzig, 1866 (Wilhelm Engelmann).—Dr. Kenngott is always thorough in his mineralogical works. This Mineralogy of the Alps contains not only notices of the localities and the associations of the species, but also extended observations on peculiarities presented by many of the minerals at their several localities, with some new crystallographic determinations. The work is therefore much more than a mere topographical mineralogy. It is full of original observations.

16. *Notes on some members of the Feldspar family;* by Isaac Lea. (From the Proc. Acad. Nat. Sci., Phil., May 1866).—Dr. Lea has here described some iridescent and other feldspars of Pennsylvania. The kinds differ somewhat in color and luster and in degree of iridescence. With the microscope he has made observations on the minute crystals of these iridescent varieties. The varieties he has observed has led him to give the name *Lennilite* to a greenish orthoclase "almost without cleavage," from Lenni, Delaware Co.; *Delawareite*, to accompanying specimens, pearly, and distinctly cleavable; and *Cassinite* to a dull bluish green, semi-transparent kind, having bright crystalline hexagonal plates within, found at Blue Hill, about two miles north of Media. Localities of sunstone and moonstone are mentioned, and some particulars respecting the microscopic crystals of different feldspars. No conclusions are arrived at in regard to the nature of the crystals.

17. *Vorlesungen über Mineralogie;* von N. von Kokscharow, Berg-Ingenieur, 1st vol., 344 pp. 4to. St. Petersburg, 1865. (A. Jacobson.) —This work is a German translation by its author from the Russian. Von Kokscharow has long been laboring with great success, and with wonderful precision through all his work, in Russian mineralogy, especially its crystallographic department. The volume just now issued is the first part of an admirable series of lessons in general mineralogy. It takes up crystallography, illustrates the subject with numerous excellent figures, many from his great work on Russian mineralogy, and throughout is both simple and thorough in its explanations. The chapter on the irregularities of crystals is particularly complete, and is made up largely of the results of his own crystallographic researches. It contains

extended tables of measurements of a considerable number of species; and is illustrated by many woodcuts, some of great beauty representing groups of Russian crystals, (chrysoberyl, etc.).

18. *On the affinities of the Bellerophontidæ;* by F. B. MEEK, (Proc. Chicago Acad. Sci., i, 9).—The Bellerophontidæ are regarded by Mr. Meek as very near Emarginula, a view suggested in 1864 by de Koninck, and adopted in 1852 by d'Orbigny, and in 1855 by Pictet. His conclusions are based on a fossil described by Professor Hall under the name *Nemanotus*. Figures of this species given in McChesney's "New Palæozoic Fossils," (there called young of Bucania Chicagoënsis), and on page 344 of the Canadian Geology (1863) show that, while it has the form of Bucania, it differs in having along the middle of the dorsal side a *row of isolated oval siphonal openings*. Mr. Meek observes that it bears the same relations to *Bucania* that *Polytremaria* does to *Pleurotomaria*, and *Rimula* to *Emarginula*. In a letter to one of the editors Mr. Meek mentions that the shell is also figured in the recent paper by Prof. Winchell, on Chicago Niagara Fossils, plate 3, figs. 7*a*, *b*.

III. BOTANY AND ZOOLOGY.

1. *Boussingault's Researches on the action of Foliage.*—A full abstract of the first part of these investigations, communicated to the French Academy of Sciences, is given in the *Comptes Rendus*, vol. lx, No. 18 (May, 1865). Theodore Saussure had long ago ascertained that, while plants prosper and decompose carbonic acid gas in an atmosphere containing as much as one-twelfth or even one-eighth part of that gas, they promptly perish in unmixed carbonic acid, apparently without decomposing any of it. Boussingault made his experiments in a better form, upon leaves only, avoiding all complication of the action of the roots or other parts of the plant. His results are:

1. That leaves exposed to sunshine in pure carbonic acid do not decompose this gas at all, or only with extreme slowness.

2. But in a mixture with atmospheric air, they decompose carbonic acid rapidly. The oxygen of the atmospheric air, however, appears to play no part.

3. Leaves decompose carbonic acid in sunshine as readily when this gas is mixed with nitrogen or with hydrogen.

Although this decomposition of carbonic acid by green foliage must be a case of dissociation,—a separation of carbon from oxygen,—yet Boussingault recognizes an analogy here with an opposite phenomenon, viz., with the slow combustion of phosphorus at the ordinary temperature. Phosphorus in pure oxygen emits no light, does not sensibly undergo combustion, but does so in a mixture of oxygen with atmospheric air, or with nitrogen, hydrogen, or carbonic acid. The analogy may even be carried farther. For while a stick of phosphorus is not phosphorescent in pure oxygen at ordinary or increased pressure, it becomes so in rarified oxygen. And Boussingault equally ascertained that leaves which exerted no sensible action upon pure carbonic acid at ordinary pressure, decomposed it, with the liberation of oxygen gas, under diminished pressure. That is, rarefaction and mixture with an inert gas act alike in mechanically separating the atoms, whether of carbonic acid as

in the one case, or of oxygen as in the other, so as to determine the action either of combination or of dissociation.

In a continuation of these investigations (*Comptes Rendus*, vol. lxi, Sept. 25, 1865), Boussingault shows that carbonic oxyd, whether pure or diluted, is not decomposable by foliage, and that this inertness of green foliage upon carbonic oxyd goes to confirm the opinion maintained in his *Economie Rurale*, that leaves simultaneously decompose carbonic acid and water, $CO^2, HO = CO, H, O^2$; the O^2 being liberated, CO, H expresses the relation under which carbon is united with the elements of water in cellulose, starch, sugar, &c., i. e., in the important principles elaborated by the leaves the composition of which is represented by carbon and water. He goes on to prove that a leaf which has been decomposing carbonic acid and water all day long is capable of doing the same work the next day, if not allowed to dry, but the losing of a certain amount of water annihilates this faculty, and irremediably destroys the life of the cells of a leaf, vegetable life in this state being far less tenacious than that of some of the lower animals (*Tardigrades*, *Notipes*, &c.) which bear wonderful desiccation.

The third instalment of the investigation is given in Nos. 16 and 17 of the same volume (Oct. 16 and 23, 1865). It appears that detached leaves, kept in shade for many days, with the cut end of the petiole in water to prevent desiccation, preserve the power of decomposing carbonic acid whenever brought into sunshine. But for this they must be kept in an atmosphere containing a supply of oxygen; without this they soon die, as Boussingault thinks, from asphyxia. This oxygen in darkness is slowly transformed into carbonic acid, through an operation which is presumed to go on continually, whether in light or darkness, and to answer to respiration. Of course a healthy and active leaf decomposes far more carbonic acid in the light than it forms in darkness. In eighteen experiments, with Oleander-leaves exposed to the sun from 8 A. M. to 5 P. M. in an atmosphere rich in carbonic acid, a square meter of foliage decomposed on the average over a liter of carbonic acid per hour, while in darkness only $\frac{7}{100}$ of a liter of carbonic acid was produced per hour. In air which contains oxygen and carbonic acid leaves will go on indefinitely producing oxygen in the presence of carbonic acid, and carbonic acid in the presence of oxygen. But the latter, though relatively small in amount, seems to be necessary to the preservation of their vitality. In hydrogen, carburetted hydrogen, or nitrogen, as well as in pure carbonic acid, they soon lose their decomposing power, and die from the impossibility of respiration, i. e., are asphyxiated.

Leaves confined in a limited portion of atmospheric or other air over mercury lose the power of decomposing carbonic acid; and the experiments pretty clearly show that they lose it through the deleterious action of the vapor of mercury. It is thought remarkable that the leaf does not under these circumstances at all lose the power of transforming oxygen into carbonic acid; but that is what we should expect, for the carbonic acid so evolved (whether its evolution be called respiration or not) must be a product of decomposition of the leaf's contents or substance.

We owe to Boussingault and his assistant Lewy the idea of determining the composition of the air contained in a fertile soil, and the fact that

this air in a strongly manured soil contains a very large percentage of carbonic acid. Boussingault has now devised an experiment by which the air contained in a branch of an Oleander in full vegetation was extracted. It proved to be nitrogen 88·01 per cent, oxygen 6·64, carbonic acid 5·35 per cent; being about the composition of the air from a well-manured soil. This carbonic acid carried into the leaves with the sap, and also that which they may absorb directly from the atmosphere, decomposed along with water under sunlight, must be the source of the glucose ($C^{12}H^{12}O^{12}$) which it is the principal function of foliage to produce. This glucose, in fixing or abandoning the elements of water, becomes sugar, starch, cellulose, or other hydrates of carbon, which, in whatever part of the plant accumulated or deposited, and however transformed or re-transformed, must always have originated from carbonic acid and water in the green parts of plants. In closing his present paper with some illustrations of this now familiar view, Boussingault announces that his more recent experiments will enable him to demonstrate the direct formation of saccharine matter by the green parts of vegetables exposed to the light. A. G.

2. *Revision of the North American species of Juncus;* by Dr. Engelmann.—No. 2 of the second volume of the *Transactions of the Academy of Science of St. Louis*, just issued, contains the following botanical papers by the indefatigable President of the Academy, viz: 1. Notes of the diagnostic characters furnished by the stone of the fruit in species of *Viburnum*, and a briefer notice of such characters in *Cornus*. 2. *Nuphar polysepalum*, a new and remarkably large-flowered species of Colorado Territory and further west, with remarks on *N. advena*, *N. luteum*, &c. This is an appendix to Dr. Parry's interesting new paper, entitled: *Notice of some additional Observations on the Physiography of the Rocky Mountains, made during the summer of* 1864. 3. And finally, this number of the Transactions is closed (on p. 458) with the 34th page of the account of our *Junci*, with which Dr. Engelmann has been occupied "since the end of last summer." The sheets now before us comprise the *generalia*, the neat systematic arrangement in a synoptical form, and the notes upon, or when needed the characters of, thirty-three of the fifty admitted North American species. Doubtless the remainder will be printed, and the memoir separately issued to botanists before this announcement is published, such is the wonderful speed with which Dr. Engelmann carries on scientific work in the midst of absorbing professional duties. For the present suffice it to say that, whereas *Juncus* has been the *dreadful* genus to North American botanists, it is likely to be dreaded no longer; that the species which at first threatened to rival *Carex* in number, are not remarkably increased by this searching revision; and, finally, that the author promises,—in case he receives the aid which we are confident his correspondents will gladly render,—to prepare and issue an "*Herbarium Juncorum Bor.-Am. Normale*, which will stand in place of expensive plates, and will, it is believed, be far preferable to them."

A. G.

3. *Lessingia germanorum.*—A friend, who knew the botanist Lessing in Berlin, informs us that Chamisso dedicated this Californian plant, not (as we have it in the last volume of this Journal, p. 263) to the botanist

and his distinguished grandfather, but to the brothers Lessing, the botanist and the painter, and so that the specific name refers not to the *Germans* but to the *brothers*. On turning to the Linnæa, however, we find all three associated in the dedication; and the specific name seems as if intended to carry a double meaning. A. G.

4. *Illustrations of the Esculent Fungi of the United States.*—We understand that our American Mycologist, Rev. Dr. M. A. Curtis, of Hillsborough, North Carolina, is preparing colored figures and descriptions of the principal eatable species of Mushrooms and other Fungi, natives of this country, with plain directions for their preparation and use. The work will be published, probably in parts, if sufficient encouragement is offered to induce a publisher to undertake it. A large amount of very nourishing and delicious food, which is wholly wasted, may be turned to good account whenever the knowledge which this work is intended to diffuse shall be made generally available. A. G.

5. *Death of Wm. Henry Harvey*, Professor of Botany in Trinity College, Dublin, and keeper of the University Herbarium.—His many friends in this country will receive with great sorrow the tidings that this distinguished Algologist as well as general botanist, and most admirable man, died of pulmonary disease, at Torquay, England, on the 15th of May, in the 56th year of his age. We may hope to present hereafter some account of his life and scientific labors. A. G.

4. *The International Horticultural Exhibition*, with a *Botanical Congress* annexed, held in London near the end of May last, appears to have been entirely successful. The managers of the Botanical Congress, which was limited to two sittings, had invited Mr. Alphonse DeCandolle to preside over its deliberations, which he did most acceptably. His address at the opening is published in the Gardener's Chronicle for May 26. In his treatment of the topics which naturally presented themselves, viz., the Advantages of Horticulture to Botany, the Advantage of Botany to Horticulture, and the beneficial Effects of the Association of Botany with Horticulture,—he rises above the commonplaces of the occasion to the consideration of important scientific questions, and to the suggestion of new modes or appliances for resolving some of them. Many of his remarks or illustrations are of such general interest that we are inclined to reprint a considerable portion of the address, if room can be found for it.

The Gardener's Chronicle for June 2 gives a list of the papers presented to the Botanical Congress, with abstracts of most of them and the details of a few. The following are those which attract our notice:

Mr. DeCandolle, the President, *On a recent very exact measurement of the diameter of the trunk of one of the gigantic Sequoias of California.* The tree was the base of "the Old Maid," the stump of which now serves as a dancing-floor; the measurement was made by Mr. De la Rue and his assistant, on a slip of paper stretched across the whole diameter of the section (26 feet, 5 inches, at 6 feet from the ground), and the rings were carefully counted and marked on the slip,—on one semi-diameter 1223, on the other 1245; the mean 1234. We imagine that this is the same tree of which we possess a similar measurement of a radius by a piece of tape, on which the centuries only are marked, making the tree about 1225 years old, as long ago recorded, we believe, in this Journal.

Prof. Caspary, of Königsberg, *On the Change in the Direction of the branches of woody plants caused by low degrees of temperature.* A full abstract of this curious paper is given; and we trust the observations will be repeated and extended in the United States and in Canada next winter. Perhaps the winter position of branches which we naturally attribute to loading with snow is partly owing to the movement which Prof. Caspary describes. The only known observation before published was made by a Mr. John Rogers in England (and recorded by Dr. Lindley in Trans. Hort. Soc. Lond., [2], ii, 230). On the remarkably cold days of January 19 and 20, 1842, when the thermometer fell to $-2°$ F. in the vicinity of London, Mr. Rogers noticed that the lower branches of a Lime-tree (*Tilia*) which overhung a part of his garden drooped so as to rest upon the ground, although there was no ice nor rime to increase their weight; and as the day advanced and grew warmer they regained their original position. Lately Von Wittich, the professor of Physiology in the University of Königsberg, noticed the same thing on a Lime-tree in his garden, and called his colleague's attention to it. Prof. Caspary found branches which were thus lowered more than three feet under a temperature of $-8\frac{1}{2}°$ F.: and last winter he proceeded to investigate the phenomenon by careful measurements, &c. We need not specify the detailed observations and experiments. The results are:

1. The branches of all trees showed a displacement in a lateral direction under severe frost, the same species moving always in the same direction, the amount of deviation increasing with the intensity of the frost. For instance, the branches of a Horse-chestnut, of a *Carpinus*, of a *Negundo*, and of a Red Buckeye moved to the left to the extent of one or two inches; those of a Lime-tree, Buckthorn, Larch, and White Pine to the right, the former as much as nearly $3\frac{1}{2}$ inches, at the point measured. (The length of the branches not stated, nor why the displacement is not given in angular deviation.)

2. The Lime, Larch, White Pine, and some others exhibited a drooping displacement as soon as frost began, and they drooped the lower as the cold grew more severe, the greatest amount of the lowering in the Lime reaching to fully three feet.

3. The branches of other species of trees begin to rise as soon as frost sets in, and rise the higher the severer the frost. Examples are *Pterocarya Caucasica* and *Negundo*.

4. The branches of other species exhibit a rising motion during mild frost, but a drooping one when the cold is intense. Such are the Horse-chestnut, Buckeye, and Buckthorn. The latter two drooped at 10° F., the Horse-chestnut only at 2° 2′ F.

As the movement, whether upwards or downwards, begins only in consequence of the heat or cold penetrating the wood, it is sooner seen in thin than in thick branches. It is remarkable that the movement begun in a direction corresponding to a certain temperature, continues in that direction even after the temperature had changed to a degree that generally produces a contrary motion. Branches in the spring were found to retain a position different from that which they had in autumn under the same temperature; the same degree of cold had at different times a different effect, not always to be accounted for by any difference in the

duration of the frost. The cause of these changes of direction Prof. Caspary is unable to explain. Of course the effect of snow, water, &c., was eliminated. The phenomenon shows that different sides of the branches are differently contracted longitudinally by low temperature; but whether the shortening on the side toward which the branch turned takes place only at the point of insertion or along its whole length, as is more probable, is not yet ascertained. The lateral deviation may be connected with the vertical by supposing the shortening of the cells along one line of the wood, this line winding more or less in consequence of the oblique or spiral direction of the cells, as exemplified in the well known twist of many stems, especially of *Coniferæ*. That young wood is differently contracted by cold in different places in the direction of the circumference and radius, Prof. Caspary showed in a paper published in the Botanische Zeitung nine years ago, and he asserts that this contraction exceeds that of all other solid bodies, even that of zinc and iron: but the longitudinal contraction has not been examined in fresh young wood. It is probably far greater than in old and dry wood, which in deal is said to be 0·00000226 or 0·0000002844 per 1° F. It might obviously be supposed that the change in the direction of the branches stands in direct connexion with that of the humidity of the air. The severe cold at Königsberg generally sets in with the east wind which is very dry; and so the times of frost, of great dryness, and of the greatest changes in the direction of the branches, happen to coincide. But it is found from a series of combined observations that, while the extremes of temperature and of change in the branches constantly coincide, those of humidity and dryness are not coincident with the extremes of change in the direction of the branches.

Mr. B. Clarke of London, *On the Floral Envelopes of Lauraceæ.* These he regards as representing calyx and corolla, and the Laurels as a sort of *Combretaceæ* with free perianth!

Dr. Hildebrand of Bonn, *On the necessity of Insect Agency in the fertilization of Corydalis cava.* Here, although the anthers and stigma are in contact, and the latter sure to be covered with pollen from the former, when protected from insects no capsules set. Moreover fruit is seldom formed when flowers of the same raceme are intercrossed. By the crossing of flowers of different plants only is perfect fertilization insured. We have been much interested this season in watching the effectual activity of so large an insect as the humble-bee in fertilizing our *Corydalis aurea.*

Mr. Howard of London, author of the *New Quinologia*, *On the Species of Cinchona.* He thinks that every well-defined district of the Andes has its own prevalent and characteristic Cinchonas, and that no one species prevails from end to end of the Cinchonaceous region. From the bark of *C. officinalis*, raised in his own stove, he obtained as large a percentage of quinine as is yielded by bark of the same age in its native country. Upon the orthography of the genus, named for the countess Chinchon, whether we are to write *Chinchona* or *Cinchona*, a discussion arose, in which Dr. Weddell remarked that if it could be proved that Linnæus left out the first *h* by accident, it should be restored; but if he deliberately wrote *Cinchona* for the sake of euphony, as is most probable,

it would set a bad precedent to alter it. Moreover as the *ch* in Spanish is not pronounced as in English, e. g., in *church*, no advantage would be gained by the alteration.

Prof. Karl Kock of Berlin, *Some Propositions with respect to Systematic Botany.* He thinks (as we do not) that needless multiplication of generic names would be hindered by the retention of the original describer's name suffixed to the species when transferred to another genus; that a system more prompt and effectual than that of Walper's *Annales* for collecting the scattered literature might be arranged, by a local botanical committee in every country to collect its scattered materials in the way of published names and descriptions, and a general editorship in some European capital to digest and publish them; that a botanico-horticultural congress might arrange to have the importers and raisers of novel plants get competent botanists to name them before they are dispersed; and that more botanists should become authority for single families, and work up the new plants introduced into cultivation, thus dividing the field of labor as astronomers have already divided the firmament.

Prof. Lecoq, of France, *On the Migration of Mountain Plants.* "The object of the author is to show that the mountains of Auvergne have received their alpine plants by the agency of birds and of wind, and not by a gradual migration during a supposed glacial period, the existence of which he denies altogether."

Prof. Schultz Schultzenstein, *On the presence and source of Nitrogen in turf and peat, with reference to its use as a manure for plants.* Having so far misunderstood "Ingenhauss, Saussure, Boussingault," and other sensible vegetable chemists as to suppose them to maintain that *because* "the mould of the soil is derived from the plants themselves," it "cannot serve them hereafter as food," he takes up the easy task of demonstrating the great usefulness of peat and mould in plant-growing; and then says, "it can be proved that the nitrogen of the turf really originates from animal bodies which live or have lived therein;"—"infusoria, polyps, worms, mollusks, crustaceans and insects ... which through their bulky development produce the nitrogen in turf-pits and in turf itself." He should go on and tell us where and how these animals obtained their nitrogen!

Mr. H. Wendland of Herrenhausen, *On the culture of Palms.* The author is the successful curator of the finest European collection of living Palms. Noting that in nature most Palms have their roots in very moist soil, he was led to depart from the ordinary custom, which has small success to recommend it, and to water his Palms abundantly, even to place pans under the pots. He concludes that most Palms cannot be destroyed by too much water, but are apt to die if water is not supplied abundantly. A. G.

7. *Illustrated Catalogue of the Museum of Comparative Zoölogy at Harvard College.* No. II. North American Acalephæ. By ALEXANDER AGASSIZ.—This work, like the preceding number on Ophiuriæ, is published in a manner highly creditable both to the institution from which it emanates, and its author. The typography is excellent, and the wood-cuts, three hundred and sixty in number, are finely executed and

printed, and although most of them are in outline they serve admirably for this class of subjects. While many of the figures have appeared before in Agassiz's Contributions, vol. iii and iv, Sea-side-Studies in Natural History, and in the Proceedings of the Boston Society of Natural History, vol. ix, very many new ones appear in this work for the first time, and illustrate many species either entirely new or imperfectly described or figured before.

In addition to the descriptions of the species there is also given a great amount of information concerning their embryological development and growth and anatomical characters, which renders the work far more valuable than a mere descriptive catalogue. The synonymy is also much more complete than usual in similar works. The author has, in fact, brought together in a condensed form nearly all the information hitherto obtained concerning the species of North America, and has added very much that is new and original.

In the general remarks concerning Ctenophoræ, the various conflicting views of authors are discussed and new facts in their embryology are brought forward to prove them to constitute actually the highest order of Acalephs, and especially to show that their bilaterality is more apparent than real. The evidence adduced seems fully sufficient to establish their true position, but we cannot see that their bilaterality is destroyed thereby, or that this conflicts with their Acalephian character, since bilaterality is also a fundamental feature of both Polyps and Echinoderms. Mr. Agassiz shows that the young Ctenophore is no more bilateral than any four-rayed jelly-fish, but becomes more so by its changes during development. The author, in fact, admits their bilateral structure when he says: "Examined in the light of prophetic beings, the bilaterality of the Acalephs is but another of those wonderful links which unite in one great whole the different members of the animal kingdom" (p. 11). But on a previous page he says: "Bilaterality seems at first sight to be the plan upon which these animals are built; but an elimination of the deceptive co-efficients will show the plan of radiation underlying this apparent bilaterality. The Ctenophoræ are compared with the larvæ of Echinoderms to show the identity of plan in the two groups.

Some observations are made indicating that possibly the orders of Discophoræ and Hydroidæ, now generally admitted, may hereafter be united into one great order, which will be equivalent in value to Ctenophoræ. At the end of the volume are remarks on the geographical distribution of Acalephs, with an enumeration of the species from the different regions.

The work is one indispensable to every one interested in this class of animals, and especially so to American naturalists, since no similar work has hitherto appeared in this country relating to Acalephs. We regret only that the genera already known, but often imperfectly characterized in previous works, have not been described in this. The reason for the omission is not apparent, since in the preceding volume on Ophiurians by Mr. Lyman, the genera, both old and new, are well characterized.

A. E. V.

8. *Fossil Medusæ.*—Professor Hæckel of Jena, who in 1865 called attention to the existence of well preserved Medusæ in the lithographic slates of Eichstadt, belonging probably to the families of Æquoridæ and

Trachynemidæ, has published, in a recent number of Leonhard & Geinitz Jahrbuch, a second notice of two other species of Medusæ so well preserved that the family to which they belong can be ascertained beyond doubt. They are from the same locality, and belong to the Discophoræ, to the family of Rhizostemidæ. The restoration which Professor Hæckel has been able to make from the specimens in his possession is quite satisfactory, and the attention of geologists having been called to this subject we may expect further interesting developments in the history of Acalephæ, since it is now well known that even at the present time a kind of petrifaction of jelly-fishes when thrown upon sandy beaches readily takes place. A. A.

9. *Polymorphism among Bryozoa.*—Dr. A. F. Smith in his inaugural dissertation, published at Upsala in 1863, has shown conclusively the existence of polymorphism amoung Bryozoa. His investigations are based upon the marine species of the Scandinavian coast. He shows that there are no less than six different forms of cells, which are probably never all found on the same stock. According to his view the Avicularia are only modified cells. Stoliczka was the first to call attention to the polymorphism of Bryozoa in his studies of fossil Bryozoa. The paper by Smith is unfortunately not illustrated, and is written in a language available to but few naturalists. A. A.

10. *Anatomy and Physiology of the Vorticellidan Parasite of Hydra* (*Trichodina pediculus* Ehr.); by Prof. H. J. Clark. (16 pp. 4to. From the Mem. read before the Bost. Soc. N. H., Vol. i, Part I. Cambridge, Feb., 1866.)—Prof. Clark, through his microscopic investigations, makes this parasite of the Hydra reveal much that is important with regard to the general structure of the Vorticellidæ, while correcting many details hitherto published respecting the species. One of the points ascertained is, that the so-called vestibular lash of the Vorticellidæ, described by some microscopists, is an optical delusion.

11. *Baird's American Birds.*—Sheets 21, 22, 23, pages 320–368, of Professor Baird's work on American Birds have been issued. They treat of the Vireonidæ, including the genera *Vireosylvia* and part of *Vireo*. The pages exhibit the same complete command of the department of American ornithology so well manifested in those that have preceded them.

12. *Notes on the Embryology of Starfishes—Tornaria;* by Alexander Agassiz. 8 pp. 8vo, with a large plate. (From the Annals of the Lyc. Nat. Hist. N. Y., vol. viii, Apr. 1866.)—This paper illustrates some points of special interest connected with the relations of starfishes to other Echinoderms.

IV. ASTRONOMY.

1. *Asteroid* (86).—On the 4th of January, 1866, Dr. F. Tietjen at Berlin discovered a new asteroid of the 12th magnitude very near to asteroid (85), whose place he was employed in determining. This planet has received the name of Semele. The following elements have been furnished by Dr. Tietjen.

1866, Jan. 8·0, Berlin mean time.

M	=	8° 23′ 14″·6	
$\pi - \Omega$	=	300 43 14 ·3	Mean equinox 1866·0
Ω	=	87 55 49 ·6	
i	=	4 47 44 ·6	
φ	=	11 49 36 ·5	
μ	=	652·9848	
log a	=	0·490069	

2. *Asteroid* (87).—On the morning of June 15, 1866, a new asteroid was discovered by Dr. C. H. F. Peters, at Hamilton College Observatory, a little brighter than stars of the twelfth magnitude. On the morning of June 21st its R. A. was $20^h\ 24^m$, and Dec. 17° 30′ S. with a slow motion toward the west.

3. *The new variable star.*—The Monthly Notices of the Royal Astronomical Society for May, 1866, contain observations of the new variable star mentioned on preceding pages of this Journal. The following results show the brightness of this star from the 15th to the 20th.

1866, May 15, at	12^h	0^m	G. M. T.	T Coronæ = 3·6 or 3·7
16, "	10	30	"	" 4·2
17, "	11	0	"	" 4·9
18, "	12	30	"	" 5·3
19, "	12	15	"	" 5·7
20, "	12	30	"	" 6·2

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Destruction of Scientific Museums by Fire.*—During the past two months two of the more valuable scientific collections of the country have been mostly destroyed by fire: that of the Lyceum of Natural History of New York, at the burning of the Academy of Music in May, and that of the Chicago Academy of Sciences on the 7th of June. The destruction of the former was complete. The following statement of the losses of the latter, is from a circular issued by the Academy, and signed Wm. Stimpson, Secretary. "As nearly as can now be ascertained the present condition of the collections and property of the Academy is as follows: About half the Mammals and Birds, and nearly all the skulls, etc., will be saved; the extensive collection of bird's eggs and nests was entirely destroyed; fishes and reptiles are saved; insects all destroyed with the exception of the Lepidoptera; dried Crustacea and Echinodermata destroyed; shells and fossils in great part saved. Very singularly and fortunately, the alcoholic collection, contained in about 2,000 jars, has escaped. The herbarium, with the exception of the series of the plants of the North Pacific Expedition, is saved. The Library is greatly damaged by water, but most of the books will be saved by careful drying and rebinding. The plates of the forthcoming volume of the Transactions, twenty in number, were much injured, and some of the edition may have to be reprinted. The publication of the volume, will not, however, be greatly delayed."

The lesson taught by these disasters should be heeded throughout the land: *make all buildings for scientific Museums thoroughly fire-proof.*

2. *Walker Prizes*—The founding of prizes by the late Dr. Wm. J. Walker, for memoirs presented to the Boston Society of Natural History, was mentioned in volume xl of this Journal, at page 137.

The following are the subjects for prizes, as recently announced:

Subject for 1866–7. "The fertilization of plants by the agency of insects, in reference both to cases where this agency is absolutely necessary, and where it is only accessory;" the investigations to be in preference directed to indigenous plants.

Subject of the annual prize for 1867–8. "Adduce and discuss the evidences of the co-existence of man and extinct animals, with the view of determining the limits of his antiquity."

Memoirs offered in competition for the above prizes must be forwarded on or before April first, prepaid and addressed "Boston Society of Natural History, for the Committee on the Walker Prizes, Boston, Mass."

Boston, June 1866.

3. *Rumford Medal.*—The Rumford Medal of the American Academy of Arts and Sciences was, on the 12th of June last, awarded to Mr. ALVAN CLARK of Cambridge, for his improvements in the making of lenses for the telescope.

4. *Prof. Henry A. Ward's Collections of Casts of Fossils, at Rochester, N. Y.*—Prof. Ward, in the course of his travels for the formation of his large Cabinet at Rochester, has had occasion to make casts of numerous fossils, large and small, from the skeletons of Elephants, Mastodons, and the Gaudeloupe Man to shells of Rhizopods; and he is consequently enabled to furnish copies of them to other cabinets. He is now issuing an illustrated catalogue of 150 pages or more, which gives some idea of the extent of his collections. His casts have already reached a number of scientific cabinets of the country, among them those of Yale, Amherst, Cambridge, Vassar College, Albany, etc.; and wherever they have gone they are admired for their excellence and perfection of finish. We would recommend to colleges, academies, and other institutions where science is taught in the land, to supply themselves, as far as they are able, with these casts. They enable the instructor to exhibit to students specimens of the rare fossil skeletons and other species of the rocks, many of which are seldom or never to be found in American collections. By means of them, series representing the principal types of different families (as that of Trilobites, or of Ammonites, etc.) may be made complete or nearly so. The casts are light and strong, and thus are well fitted for class purposes. They have been copied from the best specimens to be found in any collections, and are colored to correspond with the originals. They give at comparatively small expense wonderful effectiveness to a cabinet as a means of instruction. A gift of a collection of Mr. Ward's casts from any patron of learning to an academy or college would render great service to the instructor, the pupils, and the institution.

OBITUARY.

HENRY DARWIN ROGERS, one of the most widely known and distinguished of American Geologists, died on the 29th of May last, at Glasgow, in Scotland, where since 1857 he has held the chair of Regius Professor of Geology and Natural History. Prof. Rogers was born in

Philadelphia in 1809, being the third of four brothers all of whom have been prominent in various departments of physical science. At the early age of twenty-one years he became Prof. of Chemistry in Dickinson College, at Carlisle, in Pennsylvania, and not long after was appointed to the chair of Geology in the University of Pennsylvania. His duties as an active explorer in geology commenced, officially, with the Survey of the State of New Jersey, the Report and map of which he published in 1835. About a year later he was charged with the responsible duty of exploring and clearing up the geology of the great State of Pennsylvania, to which difficult task he devoted many years of zealous and faithful labor, aided by a large corps of able assistants. His brother, Prof. William B. Rogers, was at the same time charged with the preliminary explorations of the State of Virginia, and the great problems of the structure of the Appalachian chain were thus at the same moment brought under the observation of two of the ablest investigators of structural geology who have ever devoted their talents in that direction. The main features of this research, which for the first time opened up to view the structure of half a continent, were brought before the world in a masterly discussion of the whole subject in a joint memoir, communicated with an eloquence and fascination of style never surpassed, at a meeting of the American Association of Geologists and Naturalists held in Boston in the summer of 1842. This remarkable memoir, probably the most important of its class ever produced in America, is published in the volume of memoirs of the Association for that year. But these researches have their full and more perfect exhibition in the volumes of the final Report on the Geology of Pennsylvania, published in 1858, at Edinburgh, with the maps and sections executed in admirable style by A. Keith Johnston. This is the great work of Prof. Rogers's life and is an enduring monument of patient labor, originality and thoroughness of research, especially in the departments of structural and dynamic geology, taking rank with the labors of the best geologists of the time.

For some years previous to his becoming Professor at Glasgow, Prof. Rogers resided at Boston, devoting himself to his favorite studies, and to the public exposition of the departments of science which he cultivated.

His great knowledge on many subjects he was able to impart in a style equally clear and graceful, whether in public speaking or as a writer. Few teachers of science have excelled him in power of illustration of difficult subjects, or in commanding the attention of large audiences to themes not commonly discussed in public lectures. His contributions to scientific literature were numerous, and are found chiefly in the Transactions of the American Philosophical Society, the Journal of the Boston Society of Natural History, the Reports of the British Association and of its American equivalent, the Philadelphia Academy of Natural Sciences, in this Journal, and in the Edinburgh New Philosophical Journal, of which he was, for some years before his death, one of the Editors. A full list of all his published Memoirs and Reports fills an important page in American scientific history. So far as we now remember, Prof. Rogers was the only American who has been called to fill a scientific chair in a European University.

Prof. Rogers had for some years been in delicate health, but his

decease was unexpected. He passed most of the last winter in Boston with his brother, Prof. William B. Rogers, returning to Scotland only a short time before his death. His amiable manners and remarkable powers as a conversationalist had won for him the same social distinction in Great Britain which he long enjoyed in America, and a numerous body of personal friends deplore his loss on both sides of the Atlantic.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *Transactions of the Connecticut Academy of Arts and Sciences;* Vol. I, Part I, 248 pp. 8vo, with 3 plates. New Haven, Conn., 1866. ($2.50).—The Connecticut Academy of Arts and Sciences was organized and chartered by the State in the year 1799. In 1810 it issued the first part of Vol. I, of the "Memoirs" of the Academy, containing, among its seventeen memoirs, an article on a supposed change in the temperature of winter, by NOAH WEBSTER; on the Mineralogy of New Haven, by B. SILLIMAN; on the quantity of rain which falls on different days of the moon, by JEREMIAH DAY; on an Aurora at Durham, by Rev. ELIZUR GOODRICH; *on the Weston Meteorite*, by Profs. SILLIMAN and KINGSLEY; on the theories which have been proposed to explain the origin of meteoric stones, by Prof. J. DAY. Part. II of this volume appeared in 1811, Part III in 1813, and IV in 1816. Part III contains Prof. Silliman's paper on the fusion of refractory bodies by the compound blowpipe of Dr. Hare; and Prof. J. Day's on the comet of 1811.

Since 1816, papers read before the Academy have, to a considerable extent, found their way to the public through the American Journal of Science, the first number of which was issued in August, 1818. The Academy has now commenced a second series of publications under the title of Transactions. The volume just issued contains four papers: 1, The register of the Aurora Borealis made at New Haven by E. C. HERRICK, between March 1837 and May 1854, occupying 130 pages, with extracts from a register by FRANCIS BRADLEY; 2, Notices of Auroras, extracted from the Meteorological Journal of Rev. EZRA STILES, S.T.D., President of Yale College, made between Nov. 1763 and Nov. 1794, together with other miscellaneous notices of later date collected by Prof. E. LOOMIS; 3, on Bekker's Digammated text of Homer, by Prof. JAMES HADLEY; 4, on the mean temperature and on the fluctuations of temperature at New Haven, as deduced from 86 years of Observations, by Professors ELIAS LOOMIS and H. A. NEWTON, illustrated by three plates, one showing the mean daily curve of temperature for each month, and the other two giving chrono-isothermal lines between the mean and the highest and lowest temperature.

The Academy solicits exchange of publications from other academies, and announces on the cover of the volume that packages may be addressed to the Librarian of the Academy at New Haven.

2. *The American Annual Cyclopædia and Register of important events of the year* 1865. vol. v, large 8vo. New York, D. Appleton & Co. 1866. pp. 850.—It is highly creditable alike to the Editors and the great publishing house of Appleton that the interesting and important events of the year 1865 should so early appear in a systematic form, embracing political, civil, military and social affairs, public docu-

ments, biography, statistics, commerce, finance, literature, science, agriculture, and mechanical industry.

The chief articles on scientific subjects are treated with a good degree of fullness of detail, and for the most part with excellent judgment. Among the topics of interest to scientific men we notice the articles on astronomy, observatories, and instruments, auroras, meteors, and meteorites, including Prof. Newton's researches, and the height of the atmosphere, chemistry, chemical arts and the new nomenclature and notation of chemistry, geographical explorations and discoveries, magnesium, thallium, and the metals generally; disease of swine, the telegraph, &c. The list of American and foreign obituaries is also quite full and able. It is an important advantage to the reading public to have access to so complete a summary of scientific progress as is offered in these pages. Important omissions might be named, but they are mostly of topics which in a previous or a following year have been or may be discussed in turn.

The subjects of paramount importance in public affairs for the year 1865, such as army operations, naval affairs, and the proceedings of Congress, justly receive in this volume a larger portion of space than any others; larger, probably than they may ever do again.

3. *Chambers's Encyclopedia: a Dictionary of Universal Knowledge for the People*, on the basis of the latest edition of the German Conversations-Lexicon. Illustrated by wood-engravings and maps. Philadelphia. (J. B. Lippincott & Co.)—Parts 102–106 of Lippincott's reprint of Chambers's Encyclopedia have recently been issued. No. 106 closes volume viii, and ends with the word Sound. This number contains, among its interesting notices, an account of the recently discovered fossil bird of Solenhofen, with a woodcut. The scientific articles, with their illustrations, are an important part of this Encyclopedia.

4. *Annals of the Dudley Observatory*, Vol. I. lxvii and 126 pp. 8vo, with an appendix of [126] pages.—This volume from the Dudley Observatory contains a description of the observatory and its instruments. It opens with a landscape view in lithography, and gives full details of the structure within, illustrating its interior arrangements by woodcuts. Along with the descriptions of the instruments there are: a large copperplate engraving of the fine equatorial on a scale of one-twelfth; others of the Olcott meridian circle and its parts; one of the transit instrument made by Pistor & Martius in Berlin in 1860; others of the comet seeker; the chronographic apparatus; declinometer. Various topics are discussed which are of importance to the practical astronomer. The Appendix contains, in addition to other matters, observations of the planet Mars made at the observatory in 1862; of the planet Neptune, made in 1861; and of asteroids.

5. *Olmsted's Astronomy: an Introduction to Astronomy, designed as a Text-book for the use of Students in College;* by Denison Olmsted, LL.D., late Prof. Nat. Phil. and Astron. in Yale College. Third edition. Revised by E. S. Snell, LL.D., Prof. Nat. Phil. in Amherst College. 218 pp. 8vo, with five plates and numerous woodcuts. New York. 1866. (Collins & Brother.)—This popular text-book has undergone a new revision by Prof. Snell, much improving it. The changes consist in condensations, the omission of some historical paragraphs, a few altera-

tions in the arrangement, and the introduction largely of new engravings, some as substitutes for old cuts, and others in illustration of points not before discussed. The volume closes with some useful tables. The work is clear, simple, and sufficiently full for ordinary class instruction.

Transactions of the American Institute of the City of New York for 1864, '65. 732 pp. 8vo. Albany, 1865.

The Comstock Lode, its character and the probable mode of its continuance in depth, by F. B. RICHTHOVEN, Dr. Phil. 84 pp. 8vo. San Francisco, 1866.

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PROCEEDINGS BOSTON SOC. NAT. HIST., Vol. X.—Page 180, On the genus Belemnocrinus; *C. A. White.*—p. 102, Habits of the Halibut; *N. E. Atwood.*—p. 187, On some Odonata from the Isle of Pines; *S. H. Scudder.*—p. 200, On the spider *Nephila plumipes* and its silk as an economical product; *B. G. Wilder.*—p. 211, On some Odonata from the White Mts., N. H.; *S. H. Scudder.*—p. 223, On the Trichodina pediculus *Ehr.*; *H. J. Clark.*—p. 224, Notes on a tour in California and Nevada; *C. T. Jackson.*—p. 229, Notes on Hawaian volcano; *H. Mann.*—p. 231, On the vestibular bristle of Vorticellidæ; *H. J. Clark.*—p. 236, Earthquake at San Francisco; *W. P. Blake.*—p. 237, Elevation of Continental masses; *N. S. Shaler.*—p. 241, On the Pleistocene Glacial Climate of Europe; *H. D. Rogers.*—p. 248, List of Birds from Porto Rico; *H. Bryant.*—p. 257, New preservative solution for specimens; *A. E. Verrill.*—p. 259, Note on Geog. Distribution of N. A. birds; *A. E. Verrill.*—p. 262, Notes on California; *C. T. Jackson.*—p. 264, List of Vertebrates of Okak, Labrador, observed by Rev. S. Weiz; *A. S. Packard, Jr.*—p. 279, On the development and position of the Hymenoptera, with notes on the Morphology of Insects; *A. S. Packard.*

PROCEEDINGS CHICAGO ACAD. SCI., Vol. I.—Page 9, Note on the affinities of the Bellerophontidæ; *F. B. Meek.*—p. 11, Description of Paleozoic fossils from the Silurian, Devonian and Carboniferous of Illinois and other Western States; *Meek & Worthen.*—p. 33, On a new species of the genus Macrorhinus; *T. Gill.*—p. 46, Descriptions of new Macrurous Crustacea from the coasts of N. America; *W. Stimpson.*

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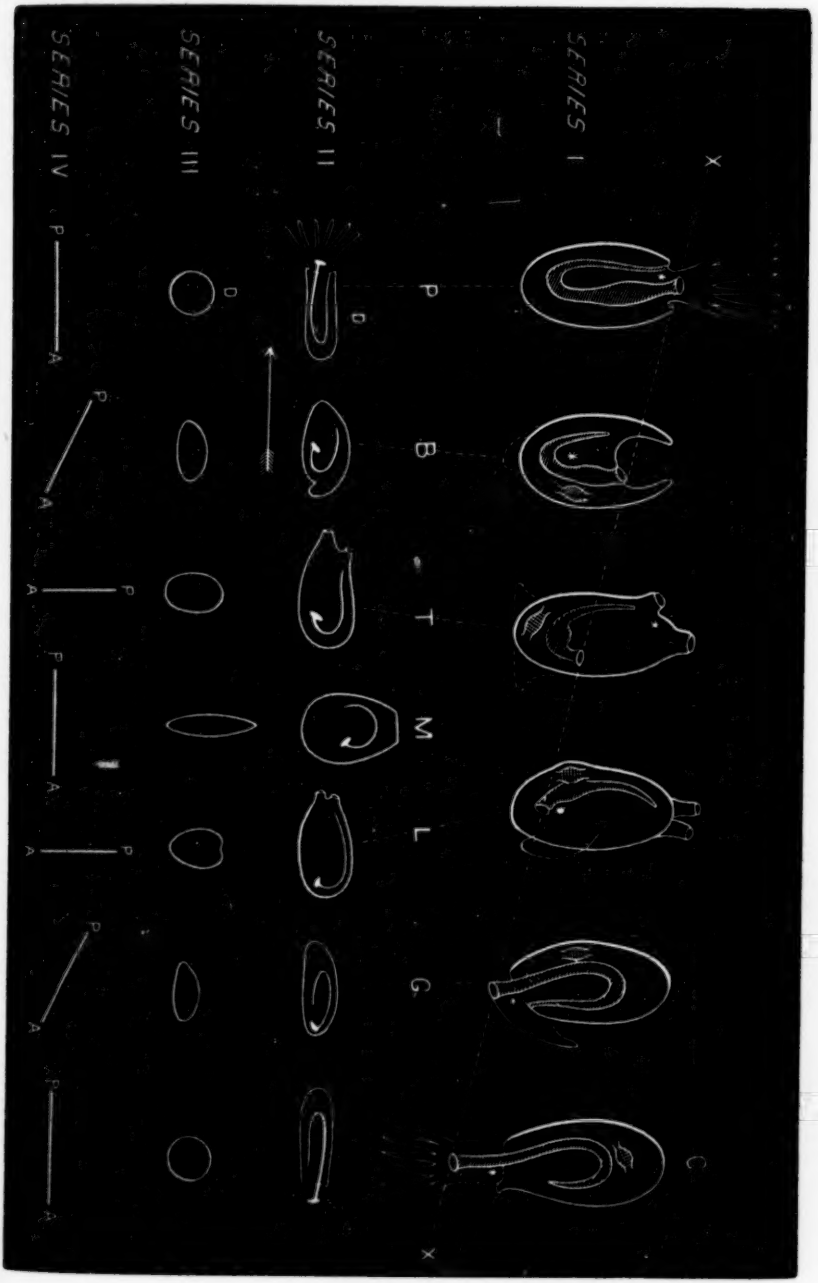
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